# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXXV. *February* 12, 1875. No. 4.

PROFESSOR J. C. ADAMS, F.R.S., President, in the Chair.

W. H. Cole, Esq., M.A., India, and Great Plumstead, Norwich;
Nathaniel E. Green, Esq., 3 Circus Road, St. John's Wood;
Don José M. Gonzalez, Paris;
E. W. Maunder, Esq., Royal Observatory, Greenwich;
W. D. Niven, Esq., M.A., Woolwich Common;
Lieut. Jelinger E. Symons, R.N., 6 Berners Street, Oxford Street; and
W. H. Thornthwaite, Esq., 3 Holborn Viaduct, E.C.;
were balloted for and duly elected Fellows of the Society.

*Report of the Council to the Fifty-fifth Annual General Meeting of the Society.*

Progress and present state of the Society:—

| | Compounders | Annual Subscribers | Non-resident | Patroness, and Honorary | Total Fellows | Associates | Grand Total |
|---|---|---|---|---|---|---|---|
| December 31, 1873 | 197 | 325 | 8 | 2 | 532 | 44 | 576 |
| Since elected ... | +8 | +33 | ... | ... | ... | 5 | .... |
| Deceased ... ... | −5 | −2 | −3 | ... | ... | −4 | ... |
| Removals ... ... | +2 | −2 | ... | ... | ... | ... | ... |
| Resigned ... ... | ... | −1 | ... | ... | ... | ... | ... |
| Expelled ... ... | ... | −10 | ... | ... | ... | ... | ... |
| December 31, 1874 | 202 | 343 | 5 | 2 | 552 | 45 | 597 |

*Mr. Whitbread's Account as Treasurer of the Royal*

RECEIPTS.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balance of last year's account ... ... ... | | | | 453 | 4 | 1 |
| By Dividend on £3,600 Consols ... ... ... | 53 | 6 | 6 | | | |
| ,, ,, £5,200 New 3 per Cents. ... | 77 | 0 | 6 | | | |
| ,, ,, £3,600 Consols ... ... ... | 53 | 11 | 0 | | | |
| ,, ,, £5,200 New 3 per Cents. ... | 77 | 7 | 0 | | | |
| | | | | 261 | 5 | 0 |
| Received for arrears of contributions ... ... | 131 | 5 | 0 | | | |
| ,, 196 Annual contributions ... ... | 411 | 12 | 0 | | | |
| ,, 46 Admission fees ... ... ... | 96 | 12 | 0 | | | |
| ,, First year's contributions ... ... | 64 | 1 | 0 | | | |
| | | | | 703 | 10 | 0 |
| ,, 10 compositions ... ... ... | | | | 210 | 0 | 0 |
| ,, Sale of publications at the Rooms of the Society ... ... ... | 24 | 6 | 9 | | | |
| ,, By Williams and Norgate, 1874 ... | 39 | 5 | 1 | | | |
| | | | | 63 | 11 | 10 |
| ,, From Indian Government, for engraving Col. Tennant's photographs ... ... ... ... | | | | 105 | 0 | 0 |
| ,, Sale of old fittings ... ... ... | | | | 5 | 0 | 0 |
| ,, Sale of £500 Consols at 92¼ (including commission) ... ... | | | | 460 | 12 | 6 |
| | | | | £2,262 | 3 | 5 |

*Astronomical Society, from Dec.* 31, 1873, *to Dec.* 31, 1874.

EXPENDITURE.

| | £ | s. | d. | £. | s. | d. |
|---|---|---|---|---|---|---|
| Salaries:— | | | | | | |
| Editor of Monthly Notices ... ... ... | 60 | 0 | 0 | | | |
| Assistant Secretary ... ... ... ... | 130 | 0 | 0 | | | |
| Commission on Collecting ... ... ... | 31 | 6 | 0 | | | |
| | | | | 221 | 6 | 0 |
| Taxes:— | | | | | | |
| Land and Assessed ... ... ... ... | 8 | 9 | 6 | | | |
| Poor and General Rates, &c. ... ... | 9 | 19 | 9 | | | |
| | | | | 18 | 9 | 3 |
| Bills:— | | | | | | |
| Spottiswoode & Co., printers ... ... | 224 | 19 | 6 | | | |
| Oxford University Press ... ... ... | 193 | 17 | 6 | | | |
| Prof. Pritchard, Sir J. Herschel's Catalogue | 20 | 0 | 0 | | | |
| Wesley, engraver ... ... ... ... | 62 | 12 | 0 | | | |
| Whiteman „ ... ... ... ... | 23 | 5 | 0 | | | |
| Mc Queen „ ... ... ... ... | 8 | 0 | 0 | | | |
| Scott „ ... ... ... ... | 8 | 0 | 0 | | | |
| Malby „ ... ... ... ... | 59 | 3 | 11 | | | |
| Pound „ ... ... ... ... | 88 | 8 | 0 | | | |
| Rumfitt, bookbinder ... ... ... ... | 16 | 7 | 6 | | | |
| Snowdon, furniture, removal, &c. ... ... | 376 | 5 | 2 | | | |
| Perry & Co., furniture and seats in meeting room, &c. ... ... ... ... | 321 | 11 | 9 | | | |
| Barry, architect ... ... ... ... | 21 | 0 | 0 | | | |
| Executors of T. W. Burr, Solicitor ... ... | 15 | 4 | 5 | | | |
| Wilson and Davis, tea and coffee services, &c. for evening meetings ... ... ... | 11 | 3 | 3 | | | |
| | | | | 1,449 | 18 | 0 |
| Miscellaneous:— | | | | | | |
| House expenses ... ... ... ... | 25 | 1 | 8 | | | |
| Stamps and postage ... ... ... ... | 54 | 17 | 2 | | | |
| Books and parcels ... ... ... ... | 4 | 4 | 6 | | | |
| Expenses of evening meetings ... ... | 17 | 10 | 0 | | | |
| Coals and gas ... ... ... ... ... | 28 | 1 | 5 | | | |
| Repairs ... ... ... ... ... | 1 | 17 | 10 | | | |
| Stationery ... ... ... ... ... | 9 | 17 | 4 | | | |
| Repacking Stock at Burlington House, &c. ... | 19 | 10 | 0 | | | |
| Sundries ... ... ... ... ... | 18 | 10 | 9 | | | |
| Bankers' Commission on cheques ... ... | 0 | 1 | 4 | | | |
| Power of Attorney for sale of £500 Consols | 0 | 11 | 6 | | | |
| Mrs. Jackson-Gwilt's annuity ... ... | 8 | 18 | 4 | | | |
| | | | | 189 | 1 | 10 |
| In hand: Petty Cash Account ... ... | | | | 16 | 9 | 4 |
| Balance at Bankers' ... ... ... ... | | | | 366 | 19 | 0 |
| | | | | £2,262 | 3 | 5 |

Examined and found correct, ARTHUR BREWIN, ROBT. J. LECKY, HENRY TOYNBEE, *Auditors.*

*January* 19, 1875.

Assets and present Property of the Society, January 1, 1875:—

| | | | | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|
| Balance at Bankers' ... ... ... ... | | | | ..... | | | 366 | 19 | 0 |
| 1 | Contribution of | 9 years' standing | ... ... | 18 | 18 | 0 | | | |
| 3 | „ | 8 „ | ... ... | 50 | 8 | 0 | | | |
| 6 | „ | 5 „ | ... ... | 63 | 0 | 0 | | | |
| 11 | „ | 4 „ | ... ... | 92 | 8 | 0 | | | |
| 17 | „ | 3 „ | ... ... | 107 | 2 | 0 | | | |
| 25 | „ | 2 „ | ... ... | 105 | 0 | 0 | | | |
| 73 | „ | 1 „ | ... ... | 153 | 6 | 0 | | | |
| | | | | | | | 590 | 2 | 0 |
| Balances in hand: Petty Cash ... ... ... ..... | | | | | | | 16 | 9 | 4 |

£5,200 New 3 per Cents. (including Mrs. Jackson-Gwilt's Gift, £300).

£3,100 Consols, including the Lee Fund (£100) and Turnor Fund (£500).

Unsold Publications of the Society.

Various astronomical instruments, books, prints, &c.

Four Gold Medals in stock.

Stock of volumes of the *Memoirs*:—

| Vol. | Total | Vol. | Total | Vol. | Total |
|---|---|---|---|---|---|
| I. Part 1 | 8 | XIV. | 361 | XXIX. | 437 |
| I. Part 2 | 49 | XV. | 165 | XXX. | 190 |
| II. Part 1 | 67 | XVI. | 276 | XXXI. | 191 |
| II. Part 2 | 29 | XVII. | 167 | XXXII. | 192 |
| III. Part 1 | 80 | XVIII. | 166 | XXXIII. | 196 |
| III. Part 2 | 99 | XIX. | 177 | XXXIV. | 159 |
| IV. Part 1 | 95 | XX. | 174 | XXXV. | 145 |
| IV. Part 2 | 102 | XXI. Part 1 | 214 | XXXVI. (with M.N.) | 221 |
| V. | 121 | XXI. Part 2 | 100 | XXXVI. (without) | 23 |
| VI. | 141 | XXI. (together) | 80 | XXXVII. Part 1 | 398 |
| VII. | 166 | XXII. | 175 | XXXVII. Part 2 | 408 |
| VIII. | 147 | XXIII. | 171 | XXXVIII. | 348 |
| IX. | 154 | XXIV. | 177 | XXXIX. Part 1 | 372 |
| X. | 167 | XXV. | 180 | XXXIX. Part 2 | 407 |
| XI. | 177 | XXVI. | 197 | XL. | ... |
| XII. | 182 | XXVII. | 449 | | |
| XIII. | 196 | XXVIII. | 410 | | |

The instruments belonging to the Society are as follow:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant, by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock, No. 1,
The *Beaufoy* clock, No. 2,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle,
The *Brisbane* circle,
The *Baker* universal equatoreal,
The *Reade* transit,
The *Matthew* equatoreal,
The *Matthew* transit,
The *South* transit,
A Sextant formerly belonging to Capt. Cook,
A Globe for showing the Precession of the *Equinoxes*.

The *Sheepshanks* collection of instruments, viz.—

1. 30-inch transit by Simms, with level and two iron stands.
2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatoreal stand and clock movement.
4. $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
6. $2\frac{3}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.*

* This instrument was lent to the late Rev. J. Cape; the Council have not been able to discover anyone who could give information as to how it has been appropriated.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff, in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.

26. Dipping needle.

27. Intensity needle.

28. Ditto ditto.

29. Box of magnetic apparatus.

30. Hassler's reflecting circle, with artificial horizon roof.

31. Box sextant and $2\frac{1}{4}$-inch glass plane artificial horizon.

32. Plane speculum artificial horizon and stand.

33. $2\frac{1}{2}$-inch circular level horizon, by Dollond.

34. Artificial horizon roof and trough.

35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T-square.

36. A pentagraph.

37. A noddy.

38. A small Galilean telescope, with the object-lens of rock-crystal.

39. Six levels, various.

40. 18-inch celestial globe.

41. Varley stand for telescope.

42. Thermometer.
43. Telescope, with the object-glass of rock crystal.

To these must be added the following instruments, which had been employed in the Observations of the Total Solar Eclipse of 1870, and which, by a resolution of the Joint Eclipse Committee of 1870, were transferred to the Royal Astronomical Society:—

Portable equatoreal stand,
Portable altazimuth tripod,
Four polarimeters,
Two Biquartz and Nicol's prisms,
Registering spectroscope, with prism,
Camera and chemicals, in box,
Two five-prism spectroscopes,
Cradle for telescope,
Eight-inch reflector and stand,
Spectroscope,
A small box, containing—
Three square-headed Nicol's prisms,
Two Babinet's compensators,
Two double-image prisms,
Three Savarts,
One positive eyepiece, with Nicol's prism,
One dark wedge.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Fuller* theodolite, to the Director of the Sydney Observatory.
The *Beaufoy* transit, to the Observatory, Kingston, Canada.

| | | |
|---|---|---|
| The *Sheepshanks* instrument, | | Nos. 1, 2, and 4, to the Astronomer Royal, for observation of the Transit of *Venus*. |
| Ditto | ditto | No. 5, to Mr. Birt. |
| Ditto | ditto | No. 8, to Rev. C. Pritchard. |
| Ditto | ditto | No. 9, to the Director of the Sydney Observatory. |
| Ditto | ditto | Nos. 11, 16, and 17 to the Astronomer Royal, for observation of the Transit of *Venus*. |
| Ditto | ditto | No. 41, to Rev. C. Pritchard. |
| Ditto | ditto | No. 43, to Mr. Huggins. |

The 6-inch circular protractor, to Mr. Birt.
Tripod stand. Mr. Chambers.
Two Savart prisms. Mr. Burton and Mr. Hunter.
Registering spectroscope, with prism. Mr. Hunter.

Lent on account of the Eclipse Expeditions of 1870 and 1871:—

| | |
|---|---|
| One polarimeter. | Mr. Ranyard. |
| One ditto. | B. A. Eclipse Committee. |
| Camera and chemicals in box. | B. A. Eclipse Committee. |
| One five-prism spectroscope. | B. A. Eclipse Committee. |
| One ditto. | Mr. Lockyer. |
| Cradle for telescope. | Mr. W. A. Harris. |

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*The Gold Medal.*

The Council have awarded the Gold Medal to Prof. D'Arrest, for his work entitled "Siderum Nebulosorum Observationes Havnienses institutæ in Specula Universitatis per Tubum Sedecimpedalem Merzianum ab Anno 1861 ad Annum 1867," and his other astronomical works. The President will explain to the Meeting the grounds of this award after the reading of the Annual Report.

*Publications of the Society.*

Volume XL. of the *Memoirs*, containing Sir John Herschel's posthumous Catalogue of Double Stars, is now published, and may be obtained by Fellows on application, in the usual manner, to the Assistant Secretary, at the apartments of the Society. Although this Catalogue does not contain the angular distances and positions of the components, yet the work will be found valuable to observers as an Index to the Double-star Catalogues from which it is compiled. The insertion of these additional data would undoubtedly have greatly enhanced the value of the Catalogue, but, after due consideration, the Editors considered it better to publish the work, with but slight modifications, as left by its illustrious compiler at the time of his lamented death.

Volume XLI., containing the collected accounts of the observations of Total Eclipses of the Sun from 1842 to 1871, is also far advanced, and the Council hope that it will be published in the current year. This volume will be a highly important one, and it will doubtless be much sought after, not only by the Fellows, but by the public generally.

Volume XLII. is also in the press, and it will contain, in addition to other papers, Colonel Tennant's Report on the Total Eclipse of the Sun of December 11-12, 1871, illustrated with fine engravings of four of the photographs taken at Dodabetta.

The volumes of the *Monthly Notices* still retain the high estimation with which they are held by astronomers of all nations.

It is exceedingly gratifying to the Council to find that their possession is so coveted by foreign astronomers, from whom repeated applications are received for their monthly transmission. Volume XXXIV., just completed, will bear comparison with any of its predecessors, not only for the number of contributions to its pages, but also for the numerous important papers which it contains, which in former years would undoubtedly have been reserved for the *Memoirs*. The advantage to authors of a speedy publication of their papers in the *Monthly Notices* has been highly appreciated; but at the same time, it is always advisable that elaborate papers containing much mathematical formulæ or tabular matter should appear in the *Memoirs*.

*The Assistant Secretary.*

Owing to the lamented death of Mr. John Williams, the late Assistant Secretary, who had faithfully served the Society for 28 years, the Council have been called upon to choose a successor. Several gentlemen well fitted for the office made application for the post, when, after the most careful consideration of the different qualifications of the candidates, the choice of the Council fell on Mr. W. H. Wesley, who will enter upon his duties soon after the anniversary meeting.

Obituary.

The Council have to report the death of the following Fellows and Associates during the past year.

Fellows:—Rev. L. P. Baker, B.D.
T. W. Burr, Esq.
Lieut. Carpendale.
W. C. Cox, Esq.
Capt. H. B. Lynch, C.B.
W. Parsonson, Esq.
Rev. H. Robinson, D.D.
J. T. Samuel, Esq.
Rev. W. Ellis Wall.
T. T. Wilkinson, Esq.

Associates:—Prof. P. A. Hansen.
Prof. J. H. von Mädler.
M. le Comte de Pontécoulant.
M. Quetelet.

The father of the late Mr. Thomas William Burr held an official appointment in the Coal Exchange in London, in which city the subject of our memoir was born on the 10th of July, 1821. He was mainly educated at a private school at Margate, kept by Mr. C. Lewis, and on attaining the age of 16 was

articled to Mr. Owen Pape Holmes, a solicitor in London. He very early exhibited a strong predilection for scientific pursuits, and, while still a youth, attained considerable proficiency in chemistry. After completing his articles in the year 1843, and being admitted a solicitor, he commenced practice in Town, and at this time took a very active part in the management of the City of London Literary and Scientific Institution, where he was contemporary with the late Sir John Bowring, Mr. Serjeant Parry, and others who have since become more or less known. He was the presiding genius, and practical head, of the philosophical class in the Institution referred to, and his untiring zeal and energy in this capacity are still remembered by all who ever came in contact with him. On April 10th, 1845, he married Mary Anne, the second daughter of Mr. Robert Greenwood (a gentleman also in the legal profession), and, for some time after this, lived—as did not a few professional men in those days—at his office in the heart of the City. At this time, or a little later, his attention would appear to have been first directed seriously to Astronomy; and he actually erected an equatoreal on a platform, on the sloping roof of a house in a dingy street, that he might pursue the practical study of our science during those hours when the great heart of the Metropolis is still, and the roar and the whirl of its traffic is hushed. After some little time, however, he took fresh chambers, and then purchased a house in Blackstock Lane, Highbury, then a rural suburb of Northern London, but now a dense mass of houses on the borders of Finsbury Park. Here he erected a regular observatory, furnished with a $3\frac{3}{8}$-inch equatoreal by Ross, a transit instrument, and a sidereal clock. He was elected a Fellow of our Society on May 13, 1853; and various communications from him will be found scattered through the volumes of our *Monthly Notices*, commencing with the XIVth. On January 25, 1854, he was elected a Member of the (now Royal) Microscopical Society, on the Council of which he afterwards repeatedly served; as he did on that of the Quekett Microscopical Club, of which he was a Vice-President. He was also a Fellow of the Chemical Society.

A keen and indefatigable worker with the microscope as well as with the telescope, his eyesight ultimately gave way under the strain, and, to his great grief and disappointment, he was peremptorily ordered by his medical advisers to discontinue observation altogether. Under these circumstances he disposed of his observatory and instruments (his equatoreal being purchased by the University of Aberdeen), and removed from Highbury to a part of Islington nearer to London. He served as a Member of our Council from February 1870 to February 1873.

He left the house in Islington, of which we have just spoken, in October 1873, and moved finally to one in St. John's Park, Upper Holloway. On his return thither on the night of

May 7th, 1874, from the Royal Italian Opera, he complained of a severe pain in his chest, and the medical man who was called in next day pronounced him to be suffering from an attack of suppressed measles—his youngest son being, as a matter of fact, ill in the house at the time with that complaint. Unhappily the diagnosis was erroneous, and it was *Angina Pectoris* with which he was seized. He seemed to rally through in the course of a week or two, and had been so markedly better during the day, on May 21st, that all around him were sanguine as to his speedy recovery. Quite suddenly, however, after midnight, he complained of acute pain near his heart, and in two minutes he was a corpse. He leaves his widow with three sons and two daughters to lament the loss of a loving husband and father; and all those who had the privilege of his acquaintance to grieve for that of an amiable and accomplished man and a sterling friend,

Lieutenant Thomas C. R. Carpendale joined the Indian Navy in 1847, at the age of fifteen or sixteen, and served in it, first as midshipman and afterwards as lieutenant, up to the date of its abolition in 1862.

He served in the Persian war of 1856, and in a Naval Brigade during the Indian Mutiny.

From 1862 up to his death, which occurred on July 16, 1870, he commanded one of the Indian Government Marine vessels, and took part in the submergence of the Persian Gulf telegraph cable in 1864, directing the course of the towing steamer.

He was a careful navigator, and hydrography is indebted to his observations for the position of more than one shoal in the Eastern seas.

He leaves a widow and young family to lament his early death.

A warm-hearted Irishman, he was much liked and esteemed by his brother officers and his men.

William Charles Cox was born in London on September 10, 1786. He was one of the senior surviving Fellows of the Society, having been elected on January 14, 1831. At this period of his life he had a considerable taste for astronomy, which enabled him throughout a long career of business as a practical optician at Devonport to employ his scientific knowledge for the advantage of those who needed assistance in connection with his business, especially of commanders of vessels belonging to that important seaport town. He was, however, of a retiring disposition, and latterly he was but little known beyond his own family circle, but his reputation as a local optician was well established, and there were but few in his neighbourhood who were more conversant with all the details of the work of a scientific instrument-maker than he was. Mr. Cox, for a very long period, was the agent at Devonport in charge of the depôt of Admiralty chronometers, and in that capacity was in frequent official communica-

tion with the Chronometer Department of the Royal Observatory. He died at Laira, near Plymouth, on April 19, 1874, in the eighty-eighth year of his age.

Peter Andreas Hansen* was born at Tondern, a town on the river Widau, in the Duchy of Schleswig, on December 8, 1795. His father was a goldsmith of that town, generally esteemed by his fellow-citizens for his integrity and benevolence, but in somewhat straitened circumstances, so that he could not afford to give his son, who showed an early and decided inclination for scientific pursuits, the education and instruction corresponding to his wishes. Young Hansen was thrown therefore in these respects very much upon his own resources. He spent much of his time after school hours in studying French and Latin, chiefly by the aid of books lent him from time to time by different friends. For mathematics and the physical sciences he exhibited an intense interest, constructing for himself the apparatus which he found useful in their acquisition so far as his means and opportunities allowed. But seeing no prospect of being able to carry out his ardent desire of entering on a scientific career, he resolved, as he grew older, to become master of the art of clock-making, an occupation in which he thought the knowledge he had obtained would be most usefully applied. With this view he joined himself to a skilful clock-maker at Flensburg, and soon showed a very considerable amount of skill and cleverness in the art. During this time he continued to spend his leisure, and frequently great part of the night, in prosecuting his scientific studies, without any assistance, and entirely self-directed. Becoming dissatisfied, however, with this occupation, in consequence of an irresistible impulse to devote himself to the sciences, he once more earnestly requested his parents to procure him the means of going to a university. He was informed that this request could not be granted; and many letters still exist, stating his deep grief at this, accompanied with expressions of the sincerest filial respect and affection for his parents. In the year 1818, having finished serving his time at Flensburg, he went by way of Tondern to Berlin, where he worked for a year with a clock-maker. Afterwards he returned to his native town, and set up a clock-making establishment at his father's house. Here he happened to make in the following year (1820), in consequence of the illness of his sister, the acquaintance of Dr. Dirks, a physician, a man who united mathematical pursuits with his professional duties. He recognised the talents of young Hansen, and succeeded at last in inducing his father to consent to his travelling to Copenhagen, and introducing himself to Professor

* The Council are indebted to M. Hansen, of Gotha, son of the late Professor Hansen, and to Madame de Mädler, of Hanover, for their courtesy in supplying, at the request of one of the Secretaries, many interesting particulars relating to the lives of Professors Hansen and Mädler.

Schumacher, who had the disposal of an appointment as calculator.

He made the journey accordingly, but when he arrived there, the post in question had been already filled up. Professor Schumacher, however, appreciated the young man's abilities, and recommended him to present himself to the king. After several audiences, he at last obtained permission to accompany Professor Schumacher in his measurement of an arc of the meridian in Holstein, but at his own expense. In the beginning of the year 1821 he worked at the calculations connected with this measurement in his native town; after which he was summoned by Schumacher to Copenhagen, and obtained for that year a salary and allowance from the Danish Government.

From 1821 to 1825 Hansen continued to act as assistant to Professor Schumacher, chiefly at Altona, where the king had had an observatory built for him, and where he spent most of his time, whilst still discharging the duties of Professor of Astronomy at Copenhagen. In the summer of 1824 he made an expedition to Heligoland, to determine the geographical position of that island. Here Hansen accompanied him, and determined the latitude at a small temporary observatory, by Bessel's method, with a Repsold transit instrument adjusted in the prime vertical. The English Government at the same time sent a vessel, with twenty-eight chronometers, to that place, for the purpose of determining the longitude from Greenwich; this commission being entrusted to Dr. Tiarks. The whole of the subsequent correspondence between Schumacher and Hansen proves their intercourse to have been of an intimate kind. The former commenced, in 1823, editing at Altona the *Astronomische Nachrichten*, which was published there until its recent removal to Kiel. Its early numbers contain numerous observations made by Hansen at Altona.

In 1825 Hansen's connection with Schumacher ceased, he being appointed to succeed the late Professor Encke as Director of the Observatory of Seeberg, near Gotha. That establishment was transferred in the year 1859 to the Erfurt suburb of the town of Gotha, on the east side of the Jägergasse, and on the north bank of the Leina Canal. Arrangements were made on this occasion for adapting the instruments to the improved methods of observing; a new Repsold equatoreal, with 6-foot telescope and 2-foot circle, being presented by the Duke, and a chronograph introduced for galvanic registration of transits. Hansen remained at the head of this establishment during the rest of his life, a period of about fifteen years, notwithstanding numerous offers made to him at different times from other places, several of which held out the prospect of considerable material advantages.

His own labours were chiefly in the department of physical astronomy, and are too well known to need a detailed description of them here, particularly as they have twice received the award of our own gold medal, in 1842 and 1860, on which occasions

respectively Lord Wrottesley and the Rev. R. Main gave very full accounts of the very important works which gained so emphatic an approval. The former of the two was principally in recognition of the masterly investigation of the mutual perturbations of *Jupiter* and *Saturn*, which, published in 1831, had already obtained the author the prize of the Royal Academy of Sciences of Berlin for that year. In acknowledging the medal of 1842, Hansen spoke of the "considerable advance" of his labours in the lunar theory, which had been also mentioned. Those labours occupied a considerable part of his time for many subsequent years; and in 1857 the lunar tables formed from the theory were published in London, at the expense of the British Government, under the author's own care, who was the guest of the Astronomer Royal at Greenwich whilst superintending their publication. The latter remarked in regard to them, on comparing a number of results obtained by their use with those given by the tables (Burckhardt's) previously employed, "Probably in no recorded instance has practical science ever advanced so far by a single stride." From that time Hansen's Lunar Tables have been used in the *Nautical Almanac* calculations, and therefore implicitly in those of the *Berliner Jahrbuch*, and other ephemerides. It is no discredit to them to say (for progress leads to a similar consequence with all human labours), that astronomers are now looking forward to their being superseded by tables still further superior in accuracy and construction. The theoretical investigations, on which they were founded, were published at Leipzig, in two parts, in 1862 and 1864. In September 1860, through the representation of the Board of Visitors of the Royal Observatory, Professor Hansen received a grant of 1,000*l.* from the British Government, as an acknowledgment of his labours in connection with the preparation of his Lunar Tables.

His curious and interesting theory of the figure of the Moon is well known, and is published in the 24th volume of our own *Memoirs*. The conclusion he arrived at (which has, however, been controverted) was that her centre of gravity does not coincide with her centre of figure, but is in a line with it on the farther side from that turned towards the Earth; a consequence of which would be, that all the air and water on the Moon (supposing any to exist) might be collected on the side which is never visible to us, making that side alone perhaps habitable.

Besides his larger works, Hansen was the author of a considerable number of detached papers, principally on points in perturbational astronomy, and on the orbits of comets and small planets. On one occasion he was engaged in rather a sharp controversy with Encke, on the accuracy of some tables of *Flora*, published at Berlin. He was a frequent contributor to the *Memoirs* of the Saxon Society of Sciences (of which he was a member), and other publications.

Professor Hansen breathed his last without suffering on the 28th of March last, in the seventy-ninth year of his age. He had been elected one of our Associates in the year 1837. W. T. L.

Johann Heinrich von Mädler, the son of a respectable citizen of Berlin, was born in that city on May 29, 1794. In infancy he was extremely delicate, and, indeed, at his birth it was scarcely thought that he was alive, or, at any rate, would survive many hours. Medical skill and great care, however, succeeded in preserving a life which must otherwise have been but of short duration, but which was destined to become so useful and so illustrious. But as he grew older, he by degrees acquired strength, and early exhibited a zeal for instruction, which was perceived with pride and satisfaction by his parents and near relatives. His mother was fond of repeating to him that her grandfather had been a professor of oriental languages at Leipzig; and her brother, Herr Strobach, a man of some considerable acquirements, especially in mathematics, frequently urged the cultivation of the talents which he perceived his nephew to possess, and assisted him in his own favourite study. Thus it was resolved to educate him with a view to becoming a tutor, and from the year 1806 he attended diligently the different classes of a gymnasium, then the best school of instruction Berlin afforded. The heads of that institution also noticed his talents, and one of them endeavoured to interest him in the study of theology, to which, however, he showed no inclination.

Most unfortunately for young Mädler, both his parents, in February 1813, fell dangerously ill of a nervous fever, which carried them off within six days. Three young sisters, of the ages of fourteen, eight, and five respectively, were left dependent upon their brother, now only eighteen years of age. The poor girls were almost despaired of, being attacked with the same complaint to which their parents succumbed, and to which also both their kind uncle Strobach and one of his sisters fell victims about the same time. Thus the care of his sisters needed all the energy and industry of Mädler, weighed down in spirits as he was by the loss of his parents, to whom he was devotedly attached, and the thoughts of whom constantly occupied his mind till they were partly diverted into another channel by those mighty political and military events which culminated in the battle of Leipzig.

It had ever been Mädler's wish to devote himself to the study of mathematics and astronomy, of which he as yet was only acquainted with the rudiments. This desire was quickened and excited when, in 1812, a university was founded at Berlin. But, as already mentioned, the loss of his parents and afterwards of his uncle compelled him to postpone for some years availing himself of the advantages thus placed so near him. Night and day he worked, alternately learning and teaching, with the double object of providing for himself and his sisters, and of acquiring the preparatory knowledge necessary for the accomplishment of his cherished wish, to begin his academical studies. At last, after five years of hard work, his perseverance was rewarded

and this wish attained. At the University of Berlin he studied mathematics under Ohm and subsequently under Dirichlet; history, geography, and languages under Junge, Ritter, and others; astronomy under Bode, and afterwards under Encke; making also the acquaintance of Humboldt, whose lectures he attended, and whose attention he attracted. Meanwhile he continued to give lessons, and in 1822 was appointed to an important tutorial post in Berlin, which he occupied, together with his other engagements, until he finally left that city.

In the year 1824 he became acquainted with Wilhelm Beer (brother of Meyerbeer and of the poet Michael Beer), a wealthy banker, who came to him for instruction in astronomy and the higher mathematics, and acquired thereby so great an interest in the former that in the year 1829 he had an observatory built near his villa, provided with an excellent achromatic by Fraunhofer, of $4\frac{1}{2}$-feet focal length, with which both tutor and pupil pursued their studies. Mädler's own first regular observations, however, were of the planet *Mars* at its opposition in 1828; these led to no satisfactory result, but were repeated some years afterwards with greater success. In 1830, after the completion of Beer's new observatory, the observations of the Moon were commenced. Mädler's original intention was to complete Lohrmann's map, but as only four sheets of that (out of twenty-five) appeared, and they required several corrections and additions, he resolved to measure and delineate himself the whole visible surface of the Moon, and this laborious scheme was completed in 600 nights, from 1830 to 1836. His cousin, Lieut. (afterwards Major) Vogel lithographed the map for him under his own eye, in four quadrants, the first of which appeared in 1834, and at once made Mädler's name famous in the astronomical world. The whole work was published in 1837, the expense, which was considerable, being most liberally defrayed by Beer. During fine nights on which the Moon was near conjunction, the new observatory was employed in physical observations of *Mars*, in determining the rotation of *Jupiter*, and on double stars.

In the year 1833 Mädler was sent by the Prussian Government, in conjunction with General von Gersdorff, to Arcona, the northern point of the island of Rügen, to make astronomical determinations of time, which were necessary for the use of the Russian chronometrical expedition. This commission was executed with success.

Mädler's meteorological observations which he made at Berlin from 1822, and which were regularly published, brought him intimately acquainted with Lichtenstein and Ritter. With them, he became one of the founders of the Berlin Geographical Society; whilst with Humboldt he constantly maintained a most friendly intercourse. The latter, in presenting Mädler with the third part of his *Cosmos*, remarked on the constant reference he had found occasion to make to him in it.

In 1838, his smaller map of the Moon (one foot in diameter)

was published; the year after his great *Selenography*. These works procured him the Lalande, as well as Danish and Prussian medals, and other honours. Shortly after he took his doctor's degree, and received the title of Royal Professor from the King of Prussia, who took the kindest interest in his labours. From 1836 he occupied the position of an observator at the Berlin Observatory, having before that taken part in the calculations. His selenographical labours, which had procured Mädler so many honours, led, by a curious coincidence, to the means by which he became acquainted with his wife. A widow lady, of the name of Witte, in Hanover, who had a great taste for astronomy, and amongst other things made a model of the Moon from her own observations, assisted by Mädler's map, hearing, in the autumn of 1839, that he was at Pyrmont, not far off, travelled there for the purpose of asking his opinion of it. She was accompanied by her eldest daughter, Minna, already known as a poetess, and the result of the visit was that Mädler not only admired her moon model (as Sir John Herschel and Humboldt both afterwards did, and which was purchased by the King of Prussia), but was induced to make a journey to Hanover, and in June of the following year married the daughter, with whom he lived most affectionately nearly thirty-four years, and who survives him. After his marriage he returned for a short time to Berlin, where his lectures during the previous winter had gained universal admiration, and attracted hearers even from Potsdam.

About this time several Directorships of Observatories fell vacant. Soldner had died at Munich, Argelander had left Helsingfors to go to Bonn, whilst W. Struve was removing from Dorpat to the newly-founded Observatory at Pulkowa, and in some other places the erection or renovation of such establishments was being discussed. Mädler received invitations from various quarters, and gave the preference to Dorpat, where he was installed in September 1840, as Professor of Astronomy and Director of the Observatory, which had been founded there by the Russian Government in 1810. This is not the place to describe that noble institution, which, under the successive direction of Struve and Mädler, has acquired so high a position amongst the Observatories of the world. The latter continued his predecessor's investigations into the motions of binary stars, with the aid of the great Fraunhofer refractor, at Dorpat (the largest made by that famous artist). He found the number of clear nights adapted to the purpose insufficient for making a larger map of the Moon, which he had projected, and therefore contented himself with a more detailed examination of certain parts, which was incorporated in a new edition of his Berlin map.

Probably Mädler's name is best known in connection with his famous theory, the so-called Central Sun hypothesis. The labours of many years, the re-observation of the 3222 stars of Bradley's *Catalogue*, with the view of determining and comparing

their proper motions, conducted him to the conclusion that there were very probable grounds for supposing that the centre of gravity of the whole sidereal universe was situated in the group of the *Pleiades*, not far from the bright star in that cluster known as *Alcyone*, and that our own Sun and solar system moves round that centre of gravity in the period of about 25 millions of years, at the distance of 5,000 billions of miles. Of course, it would be premature to accept absolutely the results of this bold and far-reaching speculation; yet, as they are no mere conjectures on his part, but founded upon a scientific consideration of a large mass of careful and accurate observations, they must claim a certain measure of probability, and will at least form a basis for further investigations, with which the name of Mädler will be for ever associated.

Twice during his residence at Dorpat he was sent by the Russian Government on a scientific expedition to observe the interesting phenomenon of a total eclipse of the Sun. The first of these was in 1851, when he selected Brest-Litowsk, in Poland, for his station; but clouds and rain disappointed his hopes and made it impossible to see the eclipse. But in 1860 he was more successful, and obtained an excellent observation of the phenomenon at Vittoria, in Spain, whither many astronomers of other nations had also repaired.

During the latter part of Mädler's tenure of office at Dorpat, he had the able assistance of Dr. Clausen. But in 1865, having completed 25 years of service there, he resigned and returned to Germany, partly from a disorder in the eyes, which incapacitated him from engaging in observations, and partly from a desire to have leisure to prosecute his great literary work, *The History of Descriptive Astronomy*, which was at last published in two volumes, in 1873, a year before his death. He went first to Wiesbaden to consult a renowned oculist there, and by a most successful operation for cataract, regained his sight, so that he could read and write, with the help of his spectacles, as before. From Wiesbaden he went to Bonn, where he resided three years; and whilst there made a journey to England, and attended the meeting of the British Association at Norwich. He always spoke afterwards with great pleasure of his visit to this country, and particularly to the Royal Observatory at Greenwich. He had been elected an Associate of our Society in 1848.

In the year 1870 he left Bonn, on account of the troubles connected with the French war, and in accordance with the wish of his wife's family, took up his residence in Hanover, where he died, on the 14th of March 1874, at the age of nearly eighty, after an illness of sixteen months, during which he suffered more than twenty cerebral apoplectic fits. His old friend and associate, W. Beer, had died as far back as 1849. W. T. L.

The following is a list of Professor Mädler's works:—

*Physische Beobachtungen des Mars.* 1830. Reprinted from the *Astronomische Nachrichten.*
*Mappa Selenographica.* Berlin, 1834–36.
*Der Mond, oder allgemeine vergleichende Selenographie.* Berlin, 1837.
*Uebersichtskarte des Mondes.* Berlin, 1837.
*Kurzgefasste Beschreibung des Mondes.* Berlin, 1838.
*Fragments sur les corps célestes du système solaire.* Paris, 1840.
*Leitfaden zur mathematischen Geographie.* Stuttgart, 1842.
*Populäre Astronomie.* Berlin, 1842 and 1861.
*Astronomical Letters.* Reprinted from the *Allgemeine Zeitung.* 3 Parts. Mitau, 1844–45.
*Hind on Comets.* Translated into German, with additions. Leipzig, 1851.
*Berechnung der totalen Sonnenfinsterniss am 28 Juli* 1851. Dorpat, 1850.
*L'éclipse solaire totale du 18 juillet* 1860.
*Ueber totale Sonnenfinsternisse.* Jena, 1861.
*Nachträge zu vorstehendem Werke.* 1862.
*Astronomie zum Schulgebrauch.* Essen, 1862.
*Beobachtungen der Univers-Sternwarte.* Vols. IX. to XV. Dorpat, 1841–63.
*Der Himmel. Astronomie zum Volksgebrauch.* Hamburg.
*Reden und Abhandlungen über Gegenstände der Himmelskunde.* Berlin, 1870.
*Geschichte der Himmelskunde, von der ältesten bis auf die neueste Zeit.* 2 Vols. Brunswick, 1873.

[What follow are on the fixed stars and sidereal universe.]

*Die Centralsonne.* First printed in the *Astronomische Nachrichten* for July 1846.
*Untersuchungen über die Fixsternsysteme.* 2 Parts. Dorpat, 1847–48.
*Katalog der 3222 Bradley'schen Sterne nach ihren Oertern berechnet.* Dorpat Observations, 1853.
*Die Eigenbewegung der Fixsterne.* Dorpat Observations, 1856.
*Beiträge zur Fixsternkunde.*
*Prize Paper of the Harlaem Society of Sciences.* 1856.
*Uebersichtstafel der Doppelsternbewegungen.* Dorpat Observations, 1857.
*Die Eigenbewegungen der Fixsterne in ihren Beziehungen zum Gesammtsystem.* Dorpat Observations, 1857.
*Der Fixsternhimmel.* Leipzig, 1858.
*Grundlagen von Mädler's Katalog der 3222 von ihm berechneten Bradley'schen Sterne.* Dorpat Observations, 1866.

Of the life of Philippe Gustave Doulcet, Comte de Pontécoulant, we have not been able to obtain many particulars. He was born in 1795, and was a scholar of the Polytechnic School

from 1811 to 1813. In the year 1829 he was awarded the prize which had been proposed by the Academy of Sciences of Paris for the calculation of the perturbations of Halley's Comet. The result of his first investigation was that the comet would be again in perihelion on the 7th of November 1835. This he afterwards corrected by taking into account the action of the Earth, and by using a more recent determination of the value of *Jupiter's* mass, and then concluded that the perihelion passage would take place on the 14th of November. It actually occurred on the 17th, three days only after his prediction.

Pontécoulant's great work, the *Théorie Analytique du Système du Monde*, was published at Paris in four volumes, the first of which appeared in 1829, and the fourth in 1846. He was the author of many other investigations in physical astronomy, which were published in the *Comptes Rendus* of the French Academy, and relate chiefly to points in the lunar theory, a subject which has exercised the talents of so many distinguished mathematicians. This led him to take part, in the year 1860, in a controversy which arose on the value of the secular acceleration of the Moon's mean motion, communications on which will be found in our own *Monthly Notices* for that year.

He held an appointment for some years during the reign of Louis Philippe as Captain, and afterwards Colonel, in the Royal Corps of the French Artillery. His death took place at his château at Pontécoulant, in the department of Calvados, on the 21st of July last. He had been elected an Associate of our Society in the year 1835.

Lambert Adolphe Jacques Quetelet was born at Gand on the 22nd of February 1796; he was educated at the lyceum of his native town, and early showed that nature had endowed him not only with a vivid imagination, but also with the precious gift of indomitable perseverance. He carried away all the prizes of his school, and at the same time wrote poetry which attracted considerable attention. At an exhibition of pictures at the Lyceum of Gand, in 1812, a drawing of his gained the first prize, and M. Cornelissen, the head of the institution, spoke of his pupil as having honoured them, "par de grands succès dans tous les genres."

Having lost his father when he was only seven years old, and his family not being any longer able to support him, he was forced to enter as a master the institution for public instruction at Audenarde. Here he remained a year, teaching mathematics, drawing, and grammar; he was then given a mastership in the lyceum of his native town. But in 1815 the lyceum was converted, by order of the Municipal Council, into a college, and Quetelet was appointed professor of mathematics; he received his nomination on his nineteenth birthday. There was nothing brilliant in the lot which had fallen to him; but his existence was now assured, heaven had answered his vows; he was now at

liberty to occupy himself with art, with literature, with science; he had time to draw, play on the flute, read Pascal, make verses, and study Newton.

In 1819 he passed his examinations for the degree of doctor of science, and amongst the themes which he sent in on the conferring of his degree was a Latin essay upon the question whether aëroliths are projected from the Moon.

In 1819 he was nominated to a professorship at the Athenæum of Brussels, and was elected almost immediately a member of the Belgian Academy. Amongst his pupils at the Athenæum were, we believe, the Duke of Saxe-Coburg and Gotha and the late Prince Consort.

In 1823 Quetelet proposed to found an observatory in Belgium; his special aptitudes pointed him out as the best person to complete the enterprise; and, thanks to the initiative of M. Falck, then Minister of the Interior, he was commissioned to go to Paris to study the practice of astronomy at the observatory there, and to visit the principal establishments of the kind in Europe. He obtained introductions to the most distinguished men of the age, Arago, Humboldt, La Place, Herschel, Schumacher, Gauss, Olbers, and others.

While waiting the completion of his plan, he, in conjunction with M. Garnier, established the periodical *La Correspondance mathématique et physique*, for which the most eminent men of the age were willing to write. This publication continued without intermission till 1839, when Quetelet was obliged to resign its supervision on account of the pressing nature of his engagements as perpetual secretary to the Academy.

The erection of the Observatory was decided upon on the 8th of June 1826. It was constructed according to the plans of Quetelet, but was not finished till after many vicissitudes, occasioned principally by the political events of 1830. He had been appointed to the directorship in 1828, but the Observatory was not completed till 1832. He then immediately commenced his labours of which it would occupy too much space to give even a list. They included meteorology, terrestrial physics, astronomy, the collection of materials for the *Annales de l'Observatoire* and for the *Annuaires*, and the other special works in which he has brought together the results of his researches.

In the early days of the Observatory all the attention of Quetelet was directed towards meteorology and terrestrial physics. The elements of these two sciences had been almost totally neglected in Belgium, and his first desire was to correct this grave error, a task in which he perfectly succeeded. M. Quetelet has given results of his persevering observations in his works, *Sur le Climat de la Belgique* and *Sur la Physique du Globe*, and thus the basis of the meteorology of Belgium was established.

From 1841 to 1845 the Observatory of Brussels was the centre of a vast meteorological network, which comprised more

than eighty stations in Europe and in the north of Asia. Its director published the results of the great undertaking, with a large number of plates, showing the course and rapidity of the atmospheric waves. But perhaps the most remarkable works of Quetelet were the papers which he published on his collections of observations of the periodic phenomena of plants and animals. These gave an impulse to similar studies throughout the whole of Europe, and he may be looked upon as the founder of a new science.

At the Observatory he also made an uninterrupted series of observations of the elements of terrestrial magnetism.

In 1853 Quetelet was appointed president of the Conférence Maritime, held at Brussels on the proposition of Lieutenant (afterwards Captain) Maury. Its purpose was to establish a system of uniform observations at sea.

In 1835 the three principal astronomical instruments of the Observatory were set up; they appear to have been a meridional instrument by Gambey, a mural circle, and an equatoreal by Troughton and Simms. The astronomical labours of the Observatory were commenced in 1836, though the small staff of the establishment and the attention given to meteorological observations did not permit of a great field of work. Quetelet occupied himself at first in fixing precisely the geographical position of the Observatory, and similar investigations were afterwards renewed when, in 1853, the difference of longitude between Brussels and Greenwich was determined by means of telegraphic signals, in 1857 between Brussels and Berlin, and in 1868 between Brussels and Leyden.

The observations made from 1837 to 1839 furnish, in the annals of the Observatory, a catalogue of 666 stars. From 1848 these observations have been undertaken with renewed ardour; but all the regularity that Quetelet desired could not be insured till 1857. From this year a great work has been carried on till the present day; we refer to a catalogue of 10,000 stars still in preparation, but which will soon be published, completing the monument raised to astronomical science by Adolphe Quetelet and his son M. Ernest Quetelet, who during nearly eighteen years has shared the work of the observatory, and thanks to his devotion, his labours have not been interrupted by the death of his father.

Adolphe Quetelet contributed greatly to the progress of the study of shooting-stars, about the nature of which little was then known. He continued to observe them to the end of his life, and he first called attention to the periodicity of the flights on the 10th of August, and stimulated astronomers of his own and other countries to make a great number of observations which, taken together, have prepared the way for the remarkable theories now formed. We are indebted to him for very valuable catalogues of the principal appearances of these meteors; and also for conscientious and precise researches on their frequency and on the several peculiarities they present.

The direction of the establishment confided to his care did not hinder him from devoting himself to studies of another order, which show the variety of his powers. We have spoken already of the eminent position he obtained in the world of science by his statistical works; it will be sufficient for us to quote his treatise on *La Physique sociale* to remind our readers of the happy application of mathematics to statistical questions. He formulated the now well-known *loi binomiale*, and insisted, more especially in his last years, on its remarkable generality. He invited the first Statistical Congress, which was held in Brussels in 1853, and was appointed its president. He was also president of the Commission of Statistics of the kingdom of Belgium. His works on social statistics brought him in 1872 the title of Associate of the Section of Moral and Political Sciences of the Institute of France. He had long been a corresponding member of this Academy.

He was member of the Royal Academy of Belgium, as we have said, from 1820, and he held the presidency of this learned body from 1832 to 1835, and then succeeded M. Dewez as perpetual secretary of its three divisions, science, literature, and the fine arts.

He inserted numerous memoirs in the publications of the Academy, and the *Bulletins* of each *séance* are, so to speak, crowded with his articles. He commenced by papers on pure mathematics; but his later memoirs are on the various subjects which we have analysed in speaking of Quetelet as director of the Observatory, and as president of the Commission of Statistics. One can see by inspection of the *Bulletins* of the Academy with what care Quetelet registered all the remarkable phenomena which presented themselves during his long career. Thanks especially to him, this publication will be always consulted with profit. The same may also be predicted of the *Annuaires* and the *Annales* of the Observatory by all those who wish closely to study the aurora borealis, shooting-stars, bolides, storms, earthquakes, and such phenomena, upon which attention is drawn so strongly at the present moment, and of which, for the most part, a complete theory has not yet been formed.

The correspondence which Quetelet had with the official heads of science in different countries contributed greatly to extend the relations of the Academy and to enrich its *Bulletins*.

In the last years of his life, when his age warned him in vain to take repose, Quetelet undertook again to realise a magnificent plan; we speak of that series of works that he successively published from 1864, and which it was his intention should be an epitome of the work of his whole life. In 1864 appeared *L'Histoire des Sciences mathématiques et physiques chez les Belges*; in 1866, *Les Sciences mathématiques et physiques chez les Belges du Commencement du XIXe Siècle*; in 1867, the *Météorologie de la Belgique comparée à celle du Globe*; in 1869, *La Physique sociale, ou Essai sur le Développement des Facultés de*

*l'Homme*; in 1870, lastly, *L'Anthropométrie, ou Mesure des différentes Facultés de l'Homme.* This did not include all the task that Quetelet imposed upon himself, and if death had not overtaken him, he would have completed the series by a new edition of his *Physique du Globe*, published in 1861, and by a treatise on Astronomy.

We will not endeavour to enumerate the learned societies of which Quetelet was a member; the list would be too long. He was elected an Associate of the Royal Astronomical Society on January 11, 1828.

Notwithstanding the numerous occupations which claimed every moment of his time, Quetelet was of easy access, and always gave the kindest reception to those who wished to speak with him on subjects connected with his studies. He could discern and would encourage merit, and many learned men will remember the support they received from him in the commencement of their career; so that he has left behind him deep regrets as well as feelings of profound gratitude.

He died on February 17, 1874, and Belgium deplored its greatest scientific luminary.*

Mr. John Williams, the late Assistant Secretary of the Royal Astronomical Society, was the only child of a partner in a prosperous manufacturing firm in the City. He was born in London on October 19, 1797, and was sent at an early age to the Charter House School, where, as a quiet and studious boy, he soon became a favourite with the masters. It is recollected of him that he had read through Rapin's History of England before he was eight years of age.

Just as he was entering into manhood his father died, and the business having declined, he was compelled to turn the education he had received to account by setting up a small school; and he shortly afterwards married the excellent wife to whose energy and careful management he frequently acknowledged that he owed much during this straitened period of his life.

The income from his school being very uncertain, he was glad, after a few years, to accept an appointment to the mastership of the parochial school in Spitalfields, which produced him a small, but regular salary.

In 1822, then in his 25th year, he became a member of the Spitalfields Mathematical Society, a venerable institution which dated from the time of Newton. During the last century, and perhaps during the first decade of this, the Society had been principally supported by weavers and dyers, who met together on the Saturday evening in their aprons and working clothes, and devoted themselves for an hour to the solution of mathematical

* The above, with the addition of a few details from the Memoir of M. Mailly, has been translated from a short life of M. Quetelet, by Dr. Terby, of Louvain.

problems. Each man had his slate, and from eight to nine silence was preserved; at nine o'clock, according to their rules, which are still preserved in the library of our Society, refreshment was to be brought in, and the rest of the evening was to be passed in mutual instruction.

At the time when Mr. Williams joined the Society it had risen in the social scale; the nucleus of a library had been collected, and they rented a building, which had formerly been a French chapel, in Crispin Street, Spitalfields, the premises consisted of three rooms, one sufficiently large to hold about 500 people. Here popular lectures were given, and 6*d*. a-head was charged for admission; one of the smaller rooms was used for the library, and the other for storing the instruments belonging to the Society. After a year or so, Mr. Williams was appointed secretary, at a very small salary. In this capacity he frequently gave lectures, one of which, on mental arithmetic, was afterwards printed, and attracted considerable attention. He also lectured on electricity, botany, geology, numismatics, and on the art of making casts of coins, at which he was a great adept. He never lost an opportunity of taking an impression from rare gems or coins which came within his reach, and in the course of his long lifetime he made a collection of some fifty thousand casts. The earlier of these are neatly executed, either in plaster of Paris or sulphur; but when electrotyping was invented, he speedily made himself a master of the art and produced thousands of copies in copper; many of them are remarkable for the beauty of their finish. We may especially mention a collection of fac-similes of large Roman brass coins, which is bound in six volumes and was founded on the famous collection of Admiral Smyth. This he often thought of reproducing by photography for publication; but, owing probably to the death of Admiral Smyth, his idea was never carried out. The principal work of this period of his life was the study of Egyptian hieroglyphics. He found that the published copies of inscriptions were frequently not to be depended upon, and this led him to the invention of an improved method of *rubbing* or copying by mechanical means inscriptions on stone, for which he received the medal of the Society of Arts. He made a large collection of rubbings; and though it required many years, as he only had his half-holidays for the work, he eventually succeeded in copying all the inscriptions on the sarcophagi and statues in the British Museum and in Sir John Soane's collection, and also those in the Ashmolean Museum at Oxford. These copies are still in existence and form a very valuable collection. His Egyptian studies led to the publication by subscription, in 1836, of his first book, *An Essay on the Egyptian Hieroglyphics*, which was the means of introducing him to Dr. Lee.

About 1840 the Mathematical Society began to decline. Many of its members left it to join the newly formed Chemical Society, the lectures dropped off, and the funds of the institution became insufficient to pay the rent of the Crispin Street building; they

therefore moved to Devonshire Street, Bishopsgate; and, in the year 1846, the Society having dwindled down to about twenty members, they gave over their library, which consisted of some three thousand volumes, to the Royal Astronomical Society. In return for this gift the then members of the Mathematical Society were elected Life Fellows of our Society, the compounding fee being remitted.

A few months after this amalgamation, Mr. Harris, the former Assistant Secretary of the Royal Astronomical Society, having died, Mr. Williams was appointed in his place.

From hieroglyphics Mr. Williams turned his attention, when he was above fifty years of age, to the study of Chinese, and after some years he succeeded in making himself master of much of their historical literature. He arranged and catalogued the Morrison Library of Chinese works for University College, and wrote several small papers on the Chinese accounts of early eclipses, and on their records of Sun-spots observed with the naked eye, which were published in the *Monthly Notices*.

But his principal work was on the Chinese observations of comets from B.C. 611 to A.D. 1640. The observations are principally extracted from the Encyclopædia of *Ma Twan Lin* and from a great historical work called the *She Ke*. It was necessary, in order to compare the dates of these observations with our own records, to construct a complete set of chronological tables, giving the succession of the dynasties and emperors from the earliest recorded times, and also tables for finding the moons and days at the different periods. Besides this, it was necessary to form a complete Chinese Celestial Atlas, and to compare their constellations with our own. Both these undertakings, each of which may be regarded as a formidable work, he successfully accomplished, and the whole was published in 1871, partly at the expense of our Society. It forms a quarto volume of about 250 pages, with lithograph plates of the Chinese constellations, and a preface of some thirty pages, which contains an important though brief sketch of early Chinese astronomy. By this work he will be remembered, and it will doubtless long remain the chief book of reference on the subject.

Besides his knowledge of Chinese, he had a considerable acquaintance with Arabic and Hebrew, and at the recent Congress of Orientalists in London his name was placed upon their Council. He was also an enthusiastic archæologist, and was a Fellow of the Society of Antiquaries; and in addition to the duties connected with our Society, he for many years filled the office of Assistant Secretary to the Microscopical Society and was, during the first years of its existence, the acting secretary of the London Photographic Society.

He was a great reader, and generally had four or five books in hand at the same time; and he never required to use a marker or to turn down a leaf, but could always find his place at once. His power of abstraction was so great that he could study

while talking was going on around him without being in the least interrupted.

He lived a quiet, happy life, always at work or reading; never idle, yet at all times willing to be interrupted for the business of the Society. He had a pleasant and obliging manner, was communicative and full of information on his favourite subjects.

His connection with the Royal Astronomical Society was a source of great pleasure to him, and he could not be persuaded to resign his post of Assistant Secretary even when he might well have done so, on the occasion of the removal of the Society from Somerset House.

The work involved in the removal of the library and the fatigue consequent upon it were very great; but he appeared to have accomplished it satisfactorily, and was settling down in his new home when the sudden loss of his wife, after a union of fifty-two years, was too much for him to bear.

Mrs. Williams died, very unexpectedly, on November 10, the Tuesday before the first meeting of the Society in Burlington House. The excitement of the week served as a stimulus which kept him up till after the funeral, but he then rapidly collapsed, and died, after three weeks of suffering, on the 3rd of December 1874, in the 78th year of his age. He was buried with his wife in Highgate Cemetery.

## Proceedings of Observatories.

The Council have received the following accounts of the proceedings of the principal Observatories.

### *Royal Observatory, Greenwich.*

The regular work with the Transit Circle and Altazimuth has been carried on as in past years, and considerable progress has been made with the Catalogue of Circumpolar Stars since the number of observations was limited to three above and three below the Pole. Observations of Coggia's Comet were made with the Transit Circle on every available opportunity last summer; the results were given in the Supplementary Number of the *Monthly Notices*.

With the Great Equatoreal a series of measures of cusps was taken during the solar eclipse of last October, from which the error of the Moon's tabular place was deduced, the corrections to the diameters of the Sun and Moon being derived from the eclipse of 1870, which was much more favourable for the determination of these elements.

The spectroscopic observations of Coggia's Comet have been already communicated to the Society, the result being to establish the identity of general *character* of its spectrum with that of the carbon compound (dioxide of carbon) with which it was compared in the same field, each exhibiting bright bands sharp on the red side, and shading off towards the blue on a continuous spectrum, which in the case of the comet was interrupted by dark lines; two of the bright bands were found to be sensibly coincident in the two spectra placed side by side. Decided polarisation, both of the coma and tail, was observed on several occasions. Drawings of the comet were made on July 9 and 13, and it was compared with these on several other occasions, but the inconvenient position of the comet made all the observations very difficult, and no measures of diameter of the nucleus, or of the jets of light in the coma, were obtained.

The new Spectroscope was received from Mr. Browning last May, and since that date the solar prominences have been mapped out as opportunity served, but the necessity of securing photographs of the Sun whenever practicable has interfered much with this class of observations. It is proposed in future to give such assistance in the photographic operations to the Spectroscopic Assistant as shall enable him to seize every opportunity which our climate affords for examining the solar chromosphere and spots with the Spectroscope.

The Royal Observatory is much indebted to Mr. Spottiswoode for his kindness in lending his powerful Automatic Spectroscope

during the adjustment of the Observatory Spectroscope. A number of measures of the displacement of lines in the spectra of stars as compared with the corresponding chemical elements have been made with the latter instrument; the motions of seven stars in the line of sight have been determined so far, and the results generally support those obtained by Mr. Huggins.

Besides this the spectra of several chemical elements have been examined under various conditions of the spark and the breadths of the lines measured; interesting changes in the spectrum of lead have thus been recorded, and in particular in the line which Mr. Huggins has used for comparison with the nebulæ, this line being seen with a low tension spark and the electrodes close together, but disappearing as the distance between them was increased. These results, which were obtained both in air and hydrogen, bear out Mr. Huggins' observations of the same line.

Great attention has been paid to photography during the past year, photographs of the Sun having been obtained on 181 days in 1874, from which 337 negatives have been selected for preservation, the rule being to keep two photographs out of those taken each day, unless where interesting changes in a spot are taking place, in which case all that are likely to be useful are preserved. Besides these Sun-pictures, which have been taken with the Kew Photoheliograph, photographs of the Moon, *Saturn*, and various stars, including some of the *Pleiades*, have been obtained with the Great Equatoreal, chiefly with the object of finding a satisfactory process for this class of work.

The volume for 1872 is published and distributed, and the printing of that for 1873 is far advanced; the reductions for 1874 are in a very forward state, and all the regular meridian work is carried on as vigorously as before the introduction of the new physical observations. Some progress has been made in the measurement of areas of Sun-spots on the photographs taken in 1873 and 1874.

The Magnetic Department has lost the services of its able Superintendent, Mr. Glaisher, who resigned at the end of 1874; he has been succeeded by Mr. Ellis, who has thus been withdrawn from the Astronomical Department, necessitating the appointment of a new Junior Assistant, who has not yet been selected by the Civil Service Commissioners. This delay has caused considerable pressure on the present staff.

The Transit of *Venus* Expeditions were despatched to their several stations last summer. The preparations required for these parties threw much additional work on the staff of the Observatory, but no interruption to the regular course of observations occurred, though it was necessary last November to detach Mr. Ellis for observation in Cornwall of the telegraph signals from Alexandria, in connection with the determination of the longitudes of Cairo, Suez, and Thebes.

*Radcliffe Observatory, Oxford.*

No change worth mentioning has taken place in the establishment or the operations of this Observatory during the last year. The same classes of observation have been kept up with the usual diligence, and the quantity of work performed does not vary much from year to year.

At the last opposition of *Jupiter* the satellites were observed as successfully as in former years; and *Mercury* has been observed twenty-one times on the meridian.

With the Transit Circle 1,500 stars have been observed during the year, and the Sun and Moon, and some of the other planets have been observed as usual. In the year 1872, 1,323 stars were observed, and in 1873 there were 1,425.

The stars observed have been recently (in addition to standard stars, and others for clock-error, zenith-point, and azimuthal-error) the double-stars of Struve's *Catalogue*, which have been observed at Oxford with the Heliometer, and stars selected from Lalande, Weisse's-Bessel, and other Catalogues in a zone extending from 50° to 53° N.P.D. Commencing with the year 1875, a new catalogue will be formed extending this zone from 53° to 63° N.P.D. In preceding years a good selection of stars was made, and observed in a zone extending from 60° to 70° N.P.D., so that, by the observations at Oxford, the whole of the stars of much practical importance (for comparison with comets and other purposes) will have been well observed in a zone 20° in breadth, and in a very important part of the northern heavens.

The revision of the places of the stars in the *British Association Catalogue*, as far as they are visible in this latitude, is essentially complete, and has led to the conclusion that the places in the *British Association Catalogue* for stars below the 6th magnitude cannot in general be relied on for even moderate accuracy, and that it may be necessary for the Society shortly to consider the expediency of the compilation of a new catalogue derived from the modern observations available since the date of the publication of the forementioned catalogue.

The Heliometer has been used as in former years for observations of binary double-stars, and for occultations of stars by the Moon and phenomena of *Jupiter's* satellites. Several series of observations of Coggia's Comet were made with it very near the time when it became invisible in high northern latitudes. A series of observations of the solar spots, made with the excellent prismatic eyepiece made by Mr. Simms for this instrument, has been begun, and will be regularly kept up for the future.

Great progress has been made with the printing during the last year. The 31st volume of the *Radcliffe Observations*, for 1871, was published early in the summer, and the following volume, for 1872, is very nearly complete. The astronomical

portion of it is complete, and the meteorological portion is very nearly so.

The reductions for 1873 are very nearly complete, and the printing of this volume will commence very shortly.

The reductions for 1874 are also in progress. The right-ascensions are completed except for the corrections to mean R.A. for the smaller stars, and the zenith-points have been completed for the observations of zenith distance for about half the year.

Meteors have been watched for by Mr. Lucas throughout the year as usual, and the observations will be printed and published in the volume for 1872 previously alluded to as being nearly ready.

### *Oxford University Observatory.*

The engineer charged with the contrivance of shutters for the revolving domes of this Observatory has met with unexpected difficulties. The building, however, is quite complete, and it is expected that new shutters will have been erected before the circulation of the present Report. The large Equatoreal and all the other instruments are ready for erection. A small transit instrument and a clock have already been arranged in their places, in order to facilitate the adjustments of the Equatoreal.

Six weeks or two months, at the latest, will, we hope, find this Observatory in active operation.

### *Cambridge Observatory.*

The observations of Argelander's stars down to the 9th magnitude, contained within the Zone between 25 and 30 degrees of North Declination, have been carried on, as far as practicable, throughout the year without intermission. In some portions of the Zone the progress of the work has been rather slow, in consequence of very many of the stars having been observed two or three times.

About 5,000 observations of these small stars have been taken in the course of the year.

In addition to these, on each night when observations are made, the requisite number of clock stars, usually five or six, and stars near the Pole for determining instrumental corrections, have been regularly observed.

The nadir-point is determined on each observing night, and the level and collimation corrections about twice a week. It may be interesting to note that during the year Zone observations have been made on exactly one hundred nights.

All these observations have been entered in the reduction books, and the reductions have made some little progress. It is satisfactory to be able to state that the discrepancy in the nadir-point of the transit circle, which has been referred to in previous

years, has at length been traced to its origin and has been entirely got rid of.

The telescope tube, which is of hammered brass, is soldered to an interior tube about three inches in length, provided with a flange by means of which it is bolted to the central cube. The observed defect was found to arise from imperfect soldering in the case of the tube which carries the eyepiece. On the 21st of May 1874, Mr. Simms connected this tube with the short interior tube by two rows of screws, and the difference in the determinations of the nadir-point, which before amounted to nearly a second and a half, was at once reduced to an insensible quantity.

A fresh determination of the intervals of the wires was made in June 1874.

Several measures of cusps were taken in the partial Solar Eclipse on the morning of October 10.

The printing of one volume of *Observations* has been completed for some time, and considerable progress has been made with a second. The Introduction is now in course of preparation.

The usual meteorological observations have been made, and have been daily communicated by telegraph to the Central Meteorological Office in London.

### *Dunsink Observatory, County Dublin.*

There is but little to record in the past year, owing to a change which has taken place in the *personnel* of the establishment. In the spring Dr. Brünnow resigned the position of Royal Astronomer of Ireland, and was succeeded by Dr. R. S. Ball, F.R.S. The former Assistant having retired, Dr. Ralph Copeland has been appointed.

The South Refractor had been in Mr. Grubb's hands for many months for alterations, but is now completed. Dr. Copeland accompanied Lord Lindsay's Transit of *Venus* Expedition to the Mauritius.

### *Durham Observatory.*

The astronomical work at this Observatory has suffered considerable interruption during the past year, both from the change of observers that took place early in the summer and from a feeling of some uncertainty as to the best method of usefully continuing astronomical observations with the very limited means at hand, both personal and instrumental.

The observation of such small planets as can be observed with the Fraunhofer Equatoreal has now been resumed, and, in addition, considerable attention will be paid to the phenomena of *Jupiter's* satellites and other occasional observations.

The usual series of meteorological observations has been continued, and communicated to the Meteorological Committee of the Royal Society.

*Royal Observatory, Edinburgh.*

During the first half, nearly, of last year, as there was only one assistant (Mr. Alex. Wallace) in the Royal Observatory, Edinburgh, much extra labour was thrown upon him and the Astronomer in keeping up unbroken the daily public service of time-ball, time-gun, and controlled clocks, as well as getting through the voluminous reductions of the bi-diurnal observations from fifty-five Meteorological stations for the monthly and quarterly returns now printed by the Registrar-General of Scotland. But during the latter half of the year, the vacant second assistantship having been filled by Her Majesty's Government, the star-catalogue computations, never entirely dropped, have again been taken effectively in hand.

A report has also been prepared, by command, for H.M. Office of Works, on the New Equatoreal, not yet out of the contractor's hands; and the whole Observatory has recently been inspected by the Chief of the Department of Government under which it is placed, viz. the Right Hon. R. A. Cross, M.P., Home Secretary, the first such visit since its establishment nearly thirty years ago.

*Glasgow Observatory.*

The operations at the Glasgow Observatory, during the year which has just elapsed, have consisted mainly in the reduction of the series of observations which has been prosecuted for some time past in connection with the construction of a Catalogue of Stars, included between the 6th and 9th magnitudes. The transit observations from 1860 to 1873 have been completely reduced, and the mean right ascensions of about six thousand stars for the common equinox of 1870·0 have hence been derived. Professor Grant is now engaged in performing a similar task with respect to the observations in north polar distance. The usual operations for the transmission of true Greenwich time to the city and port of Glasgow continue in full activity. The Observatory also continues to fulfil its part as one of the seven affiliated observatories which have been established, in connection with the Board of Trade, under the direction of a Committee of the Royal Society, with a view to the prosecution of a system of self-registering meteorological observations.

*Liverpool Observatory, Bidston, Birkenhead.*

The work of this Observatory during the past year has been largely devoted to meteorological observations, and to the testing of chronometers.

The number of instruments sent to the Observatory has been gradually on the increase; and that the practical importance of this question is being generally understood is proved by the fact, that the same chronometers are frequently sent to be re-tested after re-adjustment of the compensation by the makers.

The process of testing chronometers for five weeks in three definite temperatures, changing the temperature at the end of each week fifteen degrees, is a work of laborious detail, even with the most favoured resources of apparatus which this Observatory possesses.

Gradually this mode of determining the reliability of chronometers in various climates is assuming the form of a distinct science.

Already it has been abundantly proved that, however great perfection in the construction of chronometers mechanical skill may attain, what has been based on fixed or imperfect data must be compensated by science as well as by mechanism if the given data be suddenly or gradually changed.

Mr. Hartnup has now the clearest evidence that, by the steady prosecution of these experiments with chronometers at the Liverpool Observatory, the original aim in establishing this Observatory has been largely reached; and that the results to be obtained by this method, if generally taken up, will render a most important service to the science of Navigation.

*Temple Observatory, Rugby School.*

During the year 1874 the chief work of the Observatory has been the measurement of double stars, 412 of these having been measured by Messrs. Wilson and Seabroke. The number of nights sufficiently good for the measurement of faint, or close doubles, were very few.

With regard to spectroscopic work, the positions of the solar prominences have been noted, and rough drawings of their outlines have been made. The falling off in number and size of the prominences during the year, when compared with the observations of last year, is remarkable.

Coggia's Comet was closely watched during its summer visit, both directly and spectroscopically, and some drawings made.

The number of visitors' names entered in the Observatory Book last year is 320, chiefly members of the School, who assist, as far as possible, in double-star measures and other work; and as valuable observing hours are thus given up to educational

purposes, the quantity of work done is necessarily less than in some other observatories of amateurs.

In the spring some few members of the School attempted to photograph the Moon, and *Jupiter*, and certain stars, and some very fair photographs of the Moon were obtained, which bore enlarging to a diameter of 6 inches; those of *Jupiter* just showed the presence of belts; while those of the stars were unsuccessful.

The roof of the Observatory has for some time been getting out of shape, causing great friction on moving, and it now requires two persons to turn it round, and that, in certain positions, with difficulty. As there seems to be a prospect of a new site for the Observatory, in connection with a Temple Reading-room, it is not deemed advisable to go to great expense with the present roof, since repairs merely would be of little use.

### *Stonyhurst Observatory.*

Since the departure of the Rev. S. Perry for Kerguelen's Island, the work of the Observatory has been confined to the ordinary routine work. The 8-inch Equatoreal has, however, been employed on every available occasion in observing *Jupiter's* satellites. From January to June the instruments were placed at the service of Father Perry's companion, the Rev. W. Sidgreaves, who lost no opportunity of studying the appearance of the Sun's chromosphere with the 8-inch Equatoreal and its spectroscope, and also with a smaller equatoreal (4-inch), which has been fitted with a 10-prism direct-vision spectroscope by Browning, and sent with the Expedition to Kerguelen's Island.

The photographic records of the meteorological and magnetic instruments have been continued as usual, without intermission.

The work of reducing the magnetometer curves from the year 1868 has been committed to the Rev. J. Hawett, and considerable progress has been made.

### *Mr. Barclay's Observatory, Leyton, Essex.*

The principal work to which the 10-inch Refractor has been applied during the past year has been a continuation of double-star measures, which will be included in the next volume of *Leyton Observations*. Considering how few telescopes are now devoted to this work, it is hoped that the catalogue will be of much value.

All comets are observed as long as possible, together with occultations and phenomena of *Jupiter's* satellites.

The instrumental part of the Observatory is unchanged. The wires of the wire-micrometer have been replaced by Mr. Simms, the old ones having become stretched.

*Mr. Edward Crossley's Observatory, Skircoat, Halifax.*

The first contribution of this Observatory to the published work of the Society having been just made, it may be interesting to some of the Fellows if a short account of the instruments in use here be now given.

The Observatory is a handsome stone building, and contains four rooms. The equatoreal room is 18 feet square, and is surmounted by a cylindrical dome made of wood, and covered with sheet-copper. In this room stands a $9\frac{1}{3}$-inch equatoreal refractor by Cooke. This instrument has the usual accessories, viz. a driving-clock, parallel-wire and double-image micrometers, controlled sidereal clock, observing chairs, &c. The meridian room is 12 feet square, and contains a $3\frac{1}{2}$-feet transit circle, with declination circle 18 inches in diameter, read off by four microscopes, also by Cooke. This room has also a controlled sidereal clock. The computing room contains the books, maps, small instruments, &c.; and here also, on a brick pier, stands the standard sidereal clock. The position of the Observatory is, approximately, in 53° 42′ 9″ N. lat., and 1° 51′ 58″ W. long.

During the past year about 400 double-stars were measured, and about 100 observations of the phenomena of *Jupiter's* satellites were made. The transits of *Jupiter's* satellites, and of their shadows, were also often watched throughout. Much time, too, was spent in testing the stability and general working of the new transit circle; and in the end it was found necessary to pull it to pieces, and send it to York for alteration. But it is hoped that in a few weeks it will be ready for replacing on its piers.

*Mr. Huggins' Observatory, Upper Tulse Hill.*

Spectroscopic observations were made of the bright comet observed by Coggia from July 1 to July 15. When the slit was placed across the nucleus and coma, there was seen a broad spectrum of the same three bright bands which were seen in Comet II, 1868, and other small comets, crossed by a linear continuous spectrum of the nucleus. There was also a faint broad continuous spectrum between and beyond the bands.

1. *The spectrum of bright bands.* On some occasions, especially at the boundary of the coma, these bands were partly resolved into lines.

On July 7, 8, and 13 these bands were compared with the spectrum of sparks in olefiant gas, and with the spectrum of the lower blue part of oil flame. The three bands appeared to be displaced towards the refrangible end of the spectrum somewhat less than one-fourth of the distance between the lines $b^2$, $b^3$. This shift would indicate a motion of approach of the comet of about 40 miles per second. At the time, the comet was

approaching the earth with a velocity of about 24 miles per second.

The bright line near G which accompanies the bands in terrestrial spectra was not seen on the comet. Its relative faintness or absence may be due to the low temperature of the comet.

The spectroscope alone cannot tell us the form in which carbon exists in comets ; but the connection of their orbits with those of meteors and the presence of hydrocarbons in some meteorites would suggest that the carbon is combined with hydrogen.

2. *Continuous spectrum of the nucleus.* No dark lines or bright lines other than the three bands were detected in the spectrum of the nucleus.

The nucleus appeared as a minute point of great brilliance, with a sort of intermittent flashing light.

July 6, diameter, with power of 800, 1″·8.

July 13, 3″, but the point was less defined.

July 15, the nucleus appeared elongated towards the following side of the comet at an angle of about 40° to the axis. The nucleus appeared of an orange colour.

3. *Continuous spectrum which accompanied the gaseous spectrum.* At the boundary of the coma and in the dark space behind the nucleus this spectrum became very faint.

The greater brightness of some parts of the envelopes and of the coma were due to larger quantities of matter which give a continuous spectrum.

The more distant parts of the tail give probably a continuous spectrum only.

Polarised light was detected in every part of the comet, but did not exceed probably $\frac{1}{5}$th of the total light.

The solar radiation would be inadequate to account for the state of things in the comet directly. Is there chemical action set up by the Sun's heat ? Is the comet's light due to electricity in any form exerted by the effect of the solar radiation ? Is the source of light to be looked for in the friction of the particles of the cometary matter which had been thrown into violent agitation by the comet's approach to the Sun ?

*Lord Lindsay's Observatory, Dun Echt, Aberdeen.*

The greater part of last year was occupied with the preparations for observing the Transit of *Venus*, a large portion of the instruments of the Observatory having been taken to Mauritius for that purpose. Since the departure of the Expedition the transit circle has been in regular use, and will be principally devoted to observations of circumpolar stars. A time-gun is fired daily at noon by the mean-time clock, which is a great benefit to the immediate neighbourhood. A set of altazimuth

observations have been made to determine the latitude of the Observatory, and a few observations have been made with the heliometer.

Information has been received at the Observatory that about 270 photographs of the Transit of *Venus* have been obtained by Lord Lindsay and Mr. Gill at Mauritius, in one of which the black-drop is beautifully shown. The last contact was observed under very favourable circumstances, and several measures of least distances of the centres of the Sun and *Venus*, cusps and diameters of *Venus* were observed with the heliometer. Measures of the least distance of *Venus* from the Sun's limb with Airy's Double-Image Micrometer have also been made.

Between the 10th and 30th of November, fifteen determinations of the parallax of *Juno* have been made at Mauritius, according to the method published in the *Monthly Notices* for April 1874.

Mr. Carpenter, who has been left in charge of the Observatory at Dun Echt during the absence of the Expedition, has received a portion of the observations connected with the determination of the longitude of Lord Lindsay's station at Belmont, Mauritius, the reduction of which is rapidly progressing.

*The Earl of Rosse's Observatory, Birr Castle, Parsonstown.*

During the past year the observations of nebulæ contained in Sir J. Herschel's general catalogue have been continued, but less continuously than during the previous year, an interruption having been caused by Dr. Copeland's resignation of his post of assistant.

He has since, however, been succeeded by Mr. J. Dreyer.

Owing to the dismounting of the 3-foot reflector and the non-delivery of parts of the new mounting at the time promised, miscellaneous observations have been exceedingly few, but the time has meanwhile been well spent in getting together old work on nebulæ, with a view to future publication.

A few observations of the satellites of *Uranus* were made with the 6-foot, but *Jupiter's* meridian altitude was insufficient to afford hope of his being again observed with any success.

Meteorological observations have been made daily since January 1, 1874, at 12.45 p.m., Greenwich time, on the "Synchronous" plan, recommended by the Vienna Congress in 1873, and for the *three* other readings, viz. 8 a.m., 4 p.m., and midnight, *two*, viz. 9 a.m. and 9 p.m., have been substituted since September 1, 1874.

*Colonel Tomline's Observatory, Orwell Park, Ipswich.*

During the past year this Observatory has been fully equipped, and for the most part is now in working order. The principal instrument is an equatoreally mounted refractor of large aperture,

furnished with all the appliances necessary to render it in every respect a really useful instrument. The object-glass by Messrs. Merz, of Munich, is of 10 inches aperture. Its definition is excellent, the beauty and regularity of the diffraction rings around the stars' images being the best possible proof of the excellence of its figure. The form of mounting renders this instrument one of the most easily worked of its size yet erected. Its main characteristic consists in the polar axis being supported at its upper extremity, not by an upright column, but by a massive hollow cone, inclined at an angle with the perpendicular equal to the colatitude, surmounting a heavy metal pedestal as a base, the whole being one casting. In the centre of this the polar axis revolves, and the arrangement, therefore, allows of its complete rotation when the telescope is directed to the Pole as well as in every other position, and thus the observer has the choice of two positions from which to observe an object.

In June 1874, Mr. J. I. Plummer was appointed to the charge of the Observatory, and since that time he has endeavoured to bring the establishment into working order, but the delays of the opticians have seriously interfered with this design.

It has been determined to employ this fine instrument chiefly for the observation of comets, both periodical and occasional, and already an excellent set of observations of Comet V 1874 (Coggia's second comet) has been made, which will be published shortly. A set of drawings of Comet III 1874 (Coggia's first comet), made near the time of maximum brilliancy, has been communicated to the Society. In addition to cometary observations, Mr. Plummer hopes to undertake other astronomical work which may arise, but the observation of comets will be the chief duty of the Orwell Park Observatory, as soon as the means of doing so are satisfactorily completed.

The Observatory is provided with a small transit instrument and an excellent clock by Dent, by the aid of which it is intended to determine the longitude of the Observatory during the ensuing year. The position of the Observatory is provisionally assumed as follows:—Latitude 52° 0′ 33″ N., Longitude $4^{m}\ 55^{s}\cdot 8$ E.

### *Royal Observatory, Cape of Good Hope.*

In the last *Annual Report* a notice was given of the publication of the *Cape Catalogue* of 1,159 stars for 1860.* Copies of this work have been forwarded to England for distribution, together with copies of a paper which contains the annual mean places from January 1, 1860, to January 1, 1900, with the star

* This account of the proceedings at the Cape Observatory has been compiled from Mr. Stone's annual Report to the Lords Commissioners of the Admiralty, dated August 10, 1874, by whose permission, through the Hydrographer, the Council have been enabled to utilise it in this section of their Report.

constants from 1870 to 1880, of eight stars near the South Pole. The original intention of Mr. Stone was to afford data for the determination of the azimuthal errors at this Observatory in the reduction of the observations of stars near the South Pole made since 1870. Mr. Stone considered that the places thus prepared would be found useful to other astronomers. During the preparation of this paper, an important correction of $5^{s}\cdot4$ to the mean right ascension of $\sigma$ *Octantis*, given in the *Nautical Almanac* for 1874, was discovered. The correction has been large for many years, and has been increasing every year.

The printing of the annual results for 1859 and 1860 was stopped after the star catalogues and constants had passed through the press, in order to prevent any delay in bringing forward the *General Catalogue* for 1860. The remaining portions of the volumes for 1859 and 1860, including the Planetary results, will now, however, be soon passed through the press. The reductions of the observations made in the year 1871, with the introductory tables, are completed, and the printing will be commenced as soon as the preceding volumes are published. The reductions of the year 1872 are also completed, and the ledgers in right ascension, and N.P.D. formed. Those of 1873 are partially completed and examined.

The following is the number of stars in the Zones near the South Pole, observed since Mr. Stone commenced this work in 1871 :—

| Year. | N.P.D. of Zone. | Number of Stars observed. |
|---|---|---|
| | ° ° | |
| 1871 | 175 to 180 | 78 |
| 1872 and 1873 | 165 „ 175 | 625 |
| 1874 | 155 „ 165 | 730 |

Of the stars observed in 1874, 676 were observed three times, 14 twice, and 40 once, leaving 288 which still require observation ; these were, however, expected to be observed before the end of the year, if nothing unforeseen happened. The transits of these stars have been made by the "eye and ear" method, but in the next Zone, 145° to 155° N.P.D., it is intended to record the transits on the chronograph.

It is Mr. Stone's intention to form a catalogue of the stars observed from 1871 to 1874. This catalogue will, in addition to many bright stars, and some observed for miscellaneous purposes, contain the positions of 1,721 stars within 25° of the South Pole of not less than the 7th magnitude. The position of each star will be fixed by at least three observations. The places of the greater number of these stars have never been determined accurately before, and very few of them have been re-observed since Lacaille's time.

Observations of *Flora* for determining the solar parallax were made, at the request of Dr. Galle, on 14 nights in October and

November 1873. These observations, which were made principally by Mr. Stone himself, have been forwarded to Dr. Galle for comparison with corresponding observations made at northern observatories. They were made with the equatoreal, the mounting of which was extremely defective and unstable, but every precaution was taken to avoid any disturbance of the instrument between the observations, and Mr. Stone hopes that the results may be found of value.

Coggia's Comet (Comet III 1874) has been observed on several mornings. It was not considered desirable to make observations of this comet daily, as the determination of the places of the comparison-stars with the transit circle seriously interfered with the regular zone work. The comet has been, however, observed at intervals so long as it remained visible in the equatoreal.

The meteorological observations are in a complete state of reduction. The readings of the different instruments are taken at $0^h$, $6^h$, $12^h$, and $18^h$, for the mean results, and at $1^h\ 47^m$ for comparison with simultaneous observations throughout the world, in accordance with a scheme proposed by the American meteorologists. These results are forwarded every two months to the Meteorological Office, War Department, Washington. Monthly means of our results are also forwarded to Mr. Symons. The readings of the meteorological instruments are daily forwarded by telegraph to the Manager of the Telegraph Department, Cape Town, and then sent to all parts of the colony to which there is telegraphic communication.

The magnetical equipment ordered for this Observatory was received towards the end of January 1874. It consists of a dip instrument, with two needles, by Dover, and an unifilar magnetometer, by Elliott, combining an intensity and variation apparatus. On the receipt of these instruments Mr. Stone proceeded at once to test the constants, and to make some sets of magnetical observations. The results he obtained were, for January 1874, Dip $= 56°\ 0'{\cdot}8$; horizontal intensity $= 4{\cdot}3118$; and the variation, from a mean of four determinations, $30°\ 6'\ 23''$.

The occurrence of an Eclipse of the Sun, total in the northern parts of the colony, afforded an opportunity for attempting to throw some further light upon the constitution of the outer corona, which it was undesirable to lose, although no provision to meet the necessary expenses had been made. An application was made to the Council of this Society for the loan of instruments better suited for such work than those that were at the command of Mr. Stone, but as unfortunately the Society had no suitable instruments at the time on hand, he was thrown entirely on his own resources. Under these circumstances, Mr. Stone addressed a letter to the Governor, Sir Henry Barkly, K.C.B., on these points, the publication of which called forth an amount of co-operation which was quite unexpected. The weather, unfortunately, was not favourable at the diamond fields, where the greatest number of observers might have been expected.

Drawings, however, in strict accordance with the rules laid down, were made in Namaqualand and Basutoland, which agree so remarkably well with each other in the positions and lengths of the so-called coronal rays that the substantive character of the outer corona appears, in Mr. Stone's opinion, to be conclusively settled. Mr. Stone's observations of the Eclipse are referred to in a subsequent section of this Report.

The instruments generally are in good condition. The new mounting for the 7-inch Equatoreal has been received from Mr. Simms. The old mounting was at once taken down, and the new one placed in its position. The latter is of the most substantial character, and portions of it were sufficiently heavy to test severely the means at our command for placing them in position. The old equatoreal stood upon a granite slab fixed to a brick pier raised from the solid rock. The stability of this pier was carefully tested for a long time with cross-levels and appeared satisfactory. It was therefore determined to erect the new mounting upon this old, well settled foundation. The slab was first carefully dressed, and the holes for the lewis-bolts prepared. The heavy bottom cylinder was then placed in position upon the slab and the lewis-bolts run in with lead. To give the cylindrical rim a bearing all round, the cylinder was then partly filled with liquid Portland cement. This appeared to be desirable, for a small quantity of the cement found its way to the outside through inequalities in the stone. It would thus appear that the rim of the heavy cylinder must now have a bearing all round, either on the stone slab directly or upon the Portland cement. The whole of the mounting was erected without any accident, and Mr. Stone remarks that, with the exception of a stonemason to prepare the slab, he has had no assistance whatever, except for mere manual work, as no skilled persons capable of erecting or making the adjustments of such instruments are to be found in the colony.

During the year the Observatory has been favoured with the visits of the officers attached to several scientific Expeditions, to whom Mr. Stone has afforded every assistance required without interfering sensibly with the current work of the Observatory. At the request of Captain Nares, of H.M.S. *Challenger*, facilities were afforded to Commander Maclear and Lieutenant Bromley for making magnetical observations. The magnetical observatory was cleared, and placed entirely at the service of Commander Maclear. Before the departure of the gentlemen composing the expedition to Rodrigues for the observation of the Transit of *Venus*, time-signals were exchanged with Commander Wharton, of H.M.S. *Shearwater*, on two days with an interval of four days between them, so as to determine the rates and errors of his chronometers. Mr. De La Rue's altazimuth has been mounted at the Observatory, and observations made by Lieutenants Corbet and Coke, of the Kerguelen Expedition, to test the results, by a direct comparison with those of the transit

circle, as to the accuracy with which the local time can be determined by the altazimuth. This was done on Mr. Stone's recommendation, as he considered that on first landing at any station the local time could be determined with far greater accuracy by such an instrument than by an imperfectly mounted portable transit, as the latter must take some time before it can be adjusted. Arrangements were also made with Lieutenant Corbet for the interchange of time-signals on three days, with as large an interval as possible between, after the starting of the chronometers on board the *Volage*.

The Council have also received the following more recent report from Mr. Stone:—

Since the last report the results for 1859 and 1860, the planetary part of which had been delayed in order to bring forward the *Cape Catalogue* for 1860, have been completely printed and are in the hands of the binder.

The results for 1871 are at present being printed, and those for 1872 are ready for press.

The reductions of the observations made in 1873 are completed to "apparent place," and the constants have been prepared and examined.

Zone 155° to 165° N.P.D. of Lacaille's *Catalogue* (which contains nearly all stars to the 7th magnitude) has been completely observed within the year, at least three observations having been made of each star; and considerable advance has been made in the reductions. The number of stars observed in this zone is 1,030.

Observations of Comet III 1874, (Coggia) were made with the transit circle until October 1.

A working list has been prepared for the Zone 145° N.P.D. to 155° N.P.D., and observations of this Zone will commence in January 1875. The chronograph will then be brought into use.

The observations of *Flora* made during the opposition 1873·8 have been sent to Dr. Galle, and seem to give a result between 8″·86 and 8″·92 for the Sun's parallax, depending on the rejection or retaining of some observations.

A list of mean places from 1,860 to 1,900 of eight close polar stars has been prepared and distributed, and it is believed has been found of use by astronomers.

The first and last contacts in the eclipse of the Sun on April 16, 1874, were carefully observed.

The internal and external contacts at egress of *Venus* in her transit over the Sun on December 8 were observed with the $8\frac{1}{2}$-foot and 46-inch equatoreals, and a transit theodolite.

Observations of the Moon and Moon-culminating stars have been made since October 12, for use in determining the longitudes of the various stations for observing the Transit of *Venus*. Time-signals were given to the English, American, and German Expeditions which called at the Cape.

*Melbourne Observatory.*

The work of the Melbourne Observatory during the past year may be summarised as follows:—

The transit-circle observations include, besides the ordinary routine observations of clock-stars, &c., a series of observations of circumpolar stars and stars near the northern horizon, for the purpose of ascertaining the amount of refraction; the usual winter observations of the standard circumpolar stars; and observations of comparison-stars in connection with Coggia's Comet, and the *Flora* opposition observations. Coggia's Comet was observed from July 27 to October 6, and it is hoped to still further follow it with the great reflector.

The first Melbourne *General Catalogue* of 1,227 stars of epoch 1870 has been published.

The great Melbourne telescope has been constantly engaged, principally upon nebula work, very little lunar photography having been done for the last nine months. This instrument was used with its large parallel-wire micrometer for the observations of *Flora* and comparison-stars during the late opposition. A systematic revision of all the smaller southern nebulæ, commencing with those figured in Sir John Herschel's work, has been entered upon, and the results are already most remarkable as indicating striking changes in many of them since they were drawn by the late illustrious astronomer. Some of the later photographs of the Moon, obtained on favourable occasions with the great reflector, are excellent. Copies of these are already in the hands of some of the members of the Royal Astronomical Society, and furnish a criterion of the perfection of the 4-foot speculum now in use. Drawings of Coggia's Comet were also made by the help of this instrument.

The usual systematic observations in meteorology, terrestrial magnetism, &c. have been carried on without interruption, and the results published in the *Monthly Record of Meteorology, &c.* A volume containing the results of the year's observations, entitled *Results of Observations in Meteorology and Terrestrial Magnetism*, has also been published; besides the ordinary results, this volume contains an abstract of averages and means, which will be found of great value in connection with the climatology of the Colony.

During the past few months the preparations for observing the Transit of *Venus* have added considerably to the duties of the Observatory; and since the 1st of October regular observations of the Moon and Moon-culminating stars, and of occultations of all stars down to the 8th magnitude have been made, and will be continued till the end of January, with the view of furnishing the various southern observing Expeditions with comparison observations to assist in the determination of their longitudes.

The Government of Victoria have granted altogether 1,900*l.*

for preparations for observing the Transit of *Venus* in the Colony. The present arrangements (November 4) are as follow:—There will be three observing stations, besides the Observatory, all furnished with equatoreals and transit instruments, &c., at two of which double-image micrometer measures, as well as contact observations, will be undertaken, but at the third contact observations only will be attempted. At the Observatory it is intended to obtain double-image micrometer measures and contact observations with the new 8-inch equatoreal (lately constructed by Troughton and Simms for the Observatory), and contact observations with the 12-inch reflector. Photography will be included in the operations, and for this purpose a Dallmeyer photoheliograph, with a Janssen's apparatus, as well as the large telescope, will be used.

## Notes on some Points connected with the Progress of Astronomy during the past Year.

### *The Transit of Venus*, 1874, *December* 8–9.

The Transit of *Venus* has been successfully observed at several important stations, but, as might have been expected, very many disappointments have occurred, owing to unfavourable weather during the transit. Enough, however, has been secured to give a very good determination of the value of the solar parallax. From some of the isolated stations in the southern ocean no information has yet been received, and from others the accounts are very uncertain, so that it will probably be some time before the results of the observations at all the stations can be ascertained. The Council, therefore, cannot pretend to do more than to include in this Report a few extracts from some of the observers' notes, for which they are principally indebted to the Astronomer Royal, who has kindly permitted the extracts to be made. It is much to be regretted that at some of the principal stations the weather was so unfavourable, especially at such an important one as that at Burnham, near Christchurch, New Zealand. This station was selected as being not only appropriate for the purposes of the transit, but also for its convenient telegraphic connection with several other stations in the islands. The concise words of the telegram, "English, nothing valuable anywhere, clouds," leave us little to hope for from this station. The American party, under Dr. Peters, who observed at Queenstown, New Zealand, was more successful, and, according to the telegram, the ingress appears to have been observed, and several photographs were taken. The different phases of the transit have been observed at

several of the Russian stations, but clouds prevented any observations at some of the most important. The sky appears to have been favourable at Honolulu and Waimea, in the Sandwich Islands, but generally cloudy at Kailua in the Island of Owhyhee. The observations in Egypt and Rodrigues were successful, but no information has been received from Father Perry at Kerguelen. In India the transit has been successfully observed in many places, and especially by Colonel Tennant, at Roorkee. Very favourable telegrams have also been received from M. Janssen, at Nagasaki, in Japan, and from the French and American observers at Pekin. At Chefoo, according to the telegram, the sky was clear; observations of contacts, heliometer measures, and photographs succeeded very well. At the Auckland Islands the Sun was obscured till ten minutes after the beginning of the transit; from that time, contacts, heliometer observations, and photographs were well obtained. At Union Vala, in the Mauritius, the ingress was not observed, on account of rainy weather; forty-eight measures with the heliometer, however, were successful, as well as the first observation of the egress; at the final egress, rain again. At the Cape of Good Hope, the egress was successfully observed by Mr. Stone, especially at internal contact, when the ligament was seen by him continuously from the time it was first noticed as a thin line till apparent contact.

The following list of places has been compiled principally from telegrams received by the Astronomer Royal, or through Reuter's. It must be necessarily very imperfect; but from these localities the transit appears to have been more or less seen, and in most of them there is little doubt that the observed times of the different phases of the phenomenon have been recorded, either by eye-observation or on photographs:—

*S. E. Europe*:—Clausenberg, Maros Vasarhely, and Jassy.

*Egypt*:—Mokattam Heights near Cairo, Alexandria, Suez, and ruins of Luxor, Thebes.

*Syria and Persia.*—Beyrout, Ispahan, and Teheran.

*India*:—Indore, Kurrachee, Mooltan, Roorkee, Mussoorie, Umballa, Calcutta, and Maddapore.

*Russia in Asia*:—Wladiwostock, Arrianda, Tschita, Nertschinsk, Possiet, Habarowka, and Kiachta.

*China and Japan.*—Pekin, Chefoo, Saigon, Kobe, Nagasaki, and Yokohama.

*Java.*—Buitenzorg.

*Australia.*—Adelaide, Melbourne, and Sydney.

*New Zealand.*—Queenstown.

*Tasmania.*—Hobart Town.

*Sandwich Islands*:—Honolulu and Waimea.

*Cape of Good Hope.*—The Royal Observatory.

*Islands*:—Auckland Islands, New Caledonia, Kerguelen (German station), Mauritius, Rodrigues, and Réunion.

The preparations made under the direction of the Astronomer

Royal were of the most elaborate kind, and matters down to the smallest detail, both in connection with the scientific objects of the expedition and with the personal comforts of the observers, received the most careful consideration. The names of the five principal stations provided for by the British Government have already been given on former occasions in oral addresses to the Society by the Astronomer Royal, and in the last *Annual Report* a description was given of the instrumental equipment for each observatory. It may, however, be useful to repeat the names of the stations here, and as a permanent record of the well-devised plans of the Astronomer Royal, the names of the observers are also added both for the principal and branch stations :—

District A. Egypt :—Mokattam Heights, near Cairo. Captain C. Orde Browne, R. A., and Mr. Newton; Suez, Mr. Hunter; Luxor, near Thebes, Captain W. de W. Abney, R.E., and Colonel Campbell.

District B. Sandwich Islands :—Honolulu, Captain G. L. Tupman, R.M.A., Lieut. F. E. Ramsden, R.N., and Mr. Nichol; Kailua, Owhyhee, Professor Forbes and Mr. Barnacle; Waimea, Atooi, Mr. Johnson and Lieut. Noble, R.M.A.

District C., Rodrigues :—Lieut. Neate, R.N., Lieut. Hoggan, and Mr. Burton.

District D., New Zealand :—Burnham, near Christchurch, Major Palmer, R.E., and Lieut. Darwin, R.E.; Naseby, Otago, Lieut. Crawford, R.N.

District E., Kerguelen Island :—2 Stations. 1, Rev. S. J. Perry, Rev. W. Sidgreaves, Lieut. Goodridge, and Mr. Smith; 2, Lieut. Corbet, R.N., and Lieut. Coke, R.N.

Of these observers, Captain Browne, Captain Tupman, Lieut Neate, Major Palmer, and the Rev. S. J. Perry were the chiefs of their respective districts; and during the preparations in England, Captain Tupman was placed by the Astronomer Royal in the general charge of all the preliminary arrangements, Captain Abney having the superintendence of the photographic observations. In addition to the gentlemen mentioned above, three sappers, who had been trained to the work, were attached to each of the principal stations.

Lord Lindsay was assisted in his observations at the Mauritius by Mr. Gill, Mr. H. Davis, and Dr. R. Copeland, and a large staff of assistants, principally the crew of his yacht. Lord Lindsay was peculiarly fortunate in his choice of men, for he remarks :—"I cannot tell you how pleased I am with my men here, the crew. I could not possibly have done one-third of what I have done without them. They are all so interested and willing that it is a pleasure to work with them. I made the most complete organisation of the stations and division of labour for every man, and drilled each separately, and then all together, and I never had a single mistake during the whole time."

An outline of the general results of Lord Lindsay's observations is given in the January number of the *Monthly Notices*, which he communicated to the Society through the Astronomer Royal. Although the Sun was obscured during the first hour of the transit, and afterwards partly hid at intervals by passing clouds, a result has been obtained which Lord Lindsay and Mr. Gill consider is very satisfactory. On one of the photographs, and, fortunately, one of the finest, the last internal contact is beautifully shown.

Although the weather at Mauritius was so unfavourable at the ingress, Mr. Meldrum was enabled to secure an observation of the second and third contacts, but he was rather uncertain as to the former, owing to passing clouds.

From the reports which the Astronomer Royal has received the following extracts are taken; and the Council consider that it will be more interesting to give the accounts in the observers' language, rather than to attempt any general description of what has been seen.

*Extract from Captain Browne's Report, dated Mokattam Heights, near Cairo, December* 10, 1874.

"One word about our times of observation is necessary. I telegraphed contact with Lee $13^h\ 22^m\ 25^s$, and with De La Rue (Dallmeyer) $13^h\ 22^m\ 21^s$, actually noted as $20^s{\cdot}7$. It was based on my having the day before worked out the clock-error of the transit clock, and, with its then rate, the probable error on the morning of transit. Early that morning I set the two observing clocks to approximate sidereal time by calling seconds from the transit hut. This I considered could do no harm—they were, of course, afterwards carefully and repeatedly compared by chronometer—but they had the incidental property of being very near sidereal time, so that, without any arithmetic, I might telegraph approximate sidereal time.

"I am glad to find, however, that my clock, at comparison after observation, was one second faster than Mr. Newton's. This brings our contacts nearer together. Miss Newton observed with a 3-inch telescope belonging to her brother. She had been carefully drilled by me on the model, together with Miss Addis, whom I had posted at the Altazimuth, on a stone. Both saw the phases, and were valuable in saying just what they saw. Miss Addis failed to keep count, but Miss Newton recorded contact at a chronometer time which reduces to nearly the mean between her brother's observation and my own, thus:—

| | h | m | s |
|---|---|---|---|
| Captain Browne, with Lee . . . . | 13 | 22 | 24 |
| Mr. Newton, with De La Rue . . . | 13 | 22 | 20·7 |
| Miss Newton, with 3-in. . . . . | 13 | 22 | 22·9 |

"Considering that I am a late observer, and that I observed with a 6-inch and Miss Newton a three, I think our agreement is quite as complete as could be looked for."

The following notes, or impressions, were written immediately after the transit. Captain Browne remarks: "When I first saw *Venus* it was through a break in the cloud, and she appeared to be on the wrong path of the sun's disk. I set the finder cross-wires on the planet, and through breaks in the clouds I got *Venus* in the Airy eyepiece as a guarantee for contact setting, and changed at once to double-image. I observed diameters when I saw the planet; sometimes the edges were very waving and uncertain; now and then the definition was excellent. I considered that the double images were very distinct when their edges were good, and found that their relative depths varied with the strength of sunlight, which kept changing. I was struck by the exact similarity of the whole process to the model observation work. As the sky appeared to be clearing I obtained limb measurements, as well as might be between the clouds, occasionally without the dark wedge, but chiefly with it; but thick clouds kept disappointing me. One remained so long that I had to consider seriously whether it was safe to wait longer, or insert the Airy eyepiece. The cloud opened, and I got a few more measurements. A most alarming cloud now hid everything, and I feared that the contact might be past. The cloud again opened, and *Venus* was seen very close to the limb, but no sort of shadow of contact as yet. The shadow began to appear, and I tried to note the instant, but feared to interrupt my wife counting so near the contact. The Sun was getting brighter, apparently almost its full power, when I saw a modified short ligament form, but did not see the edges form into sharp curves and creep apart as sometimes in the model. Its blackness gathered almost gradually, and at last came an instant when it seemed to get as black as the planet, and have no light crossing it, which I noted by repeating the number of the second then called by Mrs. Browne, which she wrote down. As I continued to watch the ligament (not moving my eye from the telescope) the Sun became suddenly brighter, and I saw a sort of parting of ligament into a very narrow white line, which either became definite, or I perceived it to be definite. As the egress went on, the white line clung to the planet's edge, and at last the planet was projected past the Sun's limb with a white thread of light clearly biting into the sky. I had kept my eye on it hitherto, considering it was a phase attending the contact which must be carefully watched. Feeling convinced now that it was a light on the edge of the planet due to the atmosphere, or from some other cause, and that from its nature it was likely to continue indefinitely, I was afraid that I had thrown away the two best minutes of cusps on it, and with a feeling that I had been taken in, I began cusp measurements with the double-image, putting the direction of movement of the images exactly tangential to

the curve of the Sun's limb as possible. I then obtained a few measurements of cusps, but I found that I could not make sure of them quickly. When the cusps became very bad, I began diameters again, which I continued till *Venus* appeared to be half off, and the measures becoming uncertain. The Sun's limb was then watched till it appeared quite unbroken, which I noted as the best guess I could make at external contact.

"I cannot say sufficiently strongly how much value I think the model has been. I could hardly persuade myself I was not looking at the model. The Khedive, to whom I wrote a note telling him of our success, congratulated us, and I hear he, with others, watched the transit."

*From Mr. F. M. Newton's Report, dated from Mokattam Heights, near Cairo.*

"About $10^m$ before contact a thick cloud swept over the Sun, completely obscuring it. This, happily, cleared off about $10^s$ before contact, leaving the Sun fairly, but not well defined, owing to a slight haze following the cloud. The contact was observed through this; very little ligament. I then looked up at the clock for the minutes, having recorded the seconds of internal contact at $13^h\ 22^m\ 20^s.7$ sidereal time. On returning to the telescope I at once observed a thin line of light surrounding *Venus*' limb at that part where the contact had just taken place. My first idea was that contact had not really occurred, but I almost immediately saw the line of light projecting beyond the Sun distinctly into the sky. This appearance was permanent as long as I kept my eye to the telescope, some $80^s$ or $120^s$. I then removed my 145-power eyepiece, replacing it by one of 52-power, and observed *Venus* for the remainder of the time, till external contact. The estimated time of passage of the centre of *Venus* was $13^h\ 36^m\ 30^s$, and of last external contact at $13^h\ 51^m\ 0^s$, sidereal time. My sister was present during the observation of last external contact, and observed it with me."

*From Mr. Hunter's Report, dated Suez, December* 9, 1874.

"For some time after contact (until first recorded cusp measure at least) the edge of *Venus* was brilliantly illuminated, that edge which had just left the Sun, so that for a little I thought the Sun was appearing behind it still, although, the cusps were then well marked. It was a clear silvery light like the edge of a cloud."

"There was no distortion of the planet during the observation, except at first formation of cusps, when the points were a good deal blunted; at all other times the edges were quite sharp;

during the first limb's disappearance I saw it with the corners blunted; no blunted points observed during last limb's disappearance . . . . The time given at first internal contact might be a second or a second and a half late, as the formation of the dark line was so *instantaneous*, and at such a distance from the edge, that I took a second glance to assure myself that it was not an optical deception. There was no shading perceptible previous to this; but as the line widened at the second recorded time, there was a slight shading, which disappeared as the cusps were developed, previous to the third recorded time."

*From Colonel Campbell's Report, dated Thebes, Dec.* 18, 1874.

"On the morning of the 9th, at $6^h\ 39^m\ 43^s{\cdot}6$ local time, the Sun rose, clear and totally undisturbed by clouds or anything, over the eastern hills of Thebes—no vocal Memnon was wanted to announce the fact—and in $10^s$ I had *Venus* in the field. She looked like a blackbeetle on the Sun; of course, so low down there was much dancing and refraction, but this soon disappeared. I took a good series of micrometric measurements for distance from the Sun's limb, and for diameter; also of the cusps after contact, which I will forward to you, as well as some drawings of *Venus*, as soon as I have them all in order.

"Just before contact I noticed a faint light steal round the leading edge of *Venus* where contact was about to be made. This for the moment took me by surprise, but I immediately recognised that the light was white, like the Moon in comparison with the light of the Sun, and therefore I disregarded it in making my determination of the time of contact; about $4^s$ after this contact was made. There was hardly any black-drop, and but very slight shadow before. A few interference lines were all that could be observed, which gave but little warning, but the contact was clear and defined well. I made it take place at $8^h\ 16^m\ 10^s{\cdot}6$; Mrs. Campbell at $8^h\ 16^m\ 9^s{\cdot}5$; and Dr. Auwers at $8^h\ 16^m\ 9^s{\cdot}7$ local time.

"Dr. Döllen had kindly compared our chronometers just before and just after the observation with his five, and he gave us the corrections which I have added for local time. Mrs. Campbell was in her tent observing some distance from my tent and telescope. She had always been some $0^s{\cdot}5$ ahead of me, and Dr. Auwers was some way off each of us. Dr. Döllen was so taken aback by the light I have mentioned, that he made his observation too late, which he himself told me was $10^s$ later than the above. Admiral Ommanney's observed local time was $8^h\ 16^m\ 5^s{\cdot}6$; but he has had less practice than the other observers, and had only just taken Dr. Auwers' heliometer in hand

to look through. I consider the above times most reliable in every respect.

"*Venus* was visible over the Sun's limb for $14^m$ when half her diameter had passed. She then was only visible on the Sun; the soft light was visible all round her limb which was off the Sun, and that part of her looked like the dark part of the new Moon. The last external contact I made at $8^h\ 44^m\ 41^s{\cdot}6$; Dr. Auwers at $8^h\ 44^m\ 41^s{\cdot}9$; and an independent observer, Mr. Smith, an American resident here, at $8^h\ 44^m\ 41^s{\cdot}4$. Mrs. Campbell lost the exact moment, but estimated it at nearly the same time, perhaps $2^s$ sooner."

*From Captain Abney's Report, dated Thebes, Dec.* 10, 1874.

"One peculiarity of this transit is apparent by the absence of the black-drop; and Colonel Campbell, I find afterwards, had to *estimate* the time at which (judging from his model practice) the black-drop would have formed. This, unfortunately, was nearly $50^s$ too soon. I did not commence exposing till about $20^s$ after the signal, and after taking about 25 turns of the handle I heard Dr. Auwers' signal. Knowing that he was to give this $20^s$ before contact, I imagined I had secured the time of contact, as I telegraphed to you. The fact is, according to observation, I am at least $7^s$ short of it, and perhaps $17^s$. I think, however, that there will be enough data on the plate to enable a true determination to be made by measurement, though the limb of the Sun is not quite so steady as I should desire. The fact is, the air just after contact became very misty; so much so, that a plate taken to get the position of the cross-wires was covered all over with fog, due to the reflected light of the sky. This mist, as is well known, affects photographs much more than it does the vision in a telescope when only a moderate power is used. As to the Sun-pictures, I can hardly say of what value they may prove. Those taken half way between sunrise and contact are the best; I suppose because the mist in the air was least. *Venus* herself was also very unsteady, and will be difficult to measure.

"For external contact the signal to expose, through a mistake, was given too soon, but I am certain that on this Janssen plate there is quite sufficient data to check eye-observations. The Janssen plate taken about the time at which the centre of the planet crossed the limb, I judged for myself, and I think will be found to contain the true moment, though I, of course, cannot be certain. . . .

"I may mention a peculiarity in the appearance of *Venus* at time of contact, viz. a silver line edging the junction just at the time of contact, and after the third contact spreading some 90° to the west of it over the part outside the Sun's limb where it had

just crossed, to about its centre. At the time, in my finder, I saw the outside half of the planet wholly bright (as the new moon appears in its dark portion). The light of the line bounding *Venus* was quite peculiar, and I could only see it dimly in my finder, and very slightly in the ground glass of the heliograph. Of course I had no time to make real observations, but my ideas are completely confirmed by all the other observers. Probably at other stations the same phenomena may have been seen."

*From a letter of Dr. Auwers, dated Alexandria, January* 11, 1875.

"I got at Thebes 104 measures of the diameter of *Venus* in order to determine her figure, which I found to be sensibly circular. In the contact observations I encountered considerable difficulty, the phenomenon presenting itself dissimilar to a great extent to what it is with the model owing to a very strong crepuscular light surrounding the planet, which remained visible outside of the Sun nearly 20 minutes after internal contact; besides I met with some peculiar disturbances in the most critical time, but I think I have succeeded in observing the contact as accurately as the nature of the phenomenon permits."

*From a letter of Colonel Tennant, dated Roorkee, December* 11, 1874.

"I was up before sunrise and took a preliminary look at *Jupiter*, whose satellites looked like small comets, and the belts were hardly visible with power 125 on the 6-inch. I need hardly say that the Sun rose with terrible tremor. I saw the planet some four or five seconds after the first contact, but did not think it worth making a note of. I then began micrometer-measures of cusps, with one of your double-image micrometers, and a power of 128, and one revolution $=16''{\cdot}076$. With this I got 16 measures of the chord joining the cusps at ingress. The internal contact rather surprised me, as I was intent on my measures, and could not get the key for the chronograph, but I noted the time by dial.

"I then got 26 measures of the distance of the limbs, and 68 measures of the diameter of *Venus*. Again 16 measures of the distance of limbs, the internal contact, and 16 measures of the chord at egress, and last contact. During the whole time the tremor was very great, and not only did the whole move, but the two images were rapidly oscillating with respect to each other in all directions. Still I think my results are very fairly accordant, and I should consider them first class with any other micrometer.

"I used the full aperture of the 6-inch, and neither at ingress nor egress did I observe any trace of a black-drop. The

final line of light at the last phenomenon was, and the cusps were, as fine as the diameter of a small star-disk, and it melted away. Captain Campbell observed with the great theodolite, and observed the ingress internally within two seconds of my time. He was using only two inches of aperture, and saw some phenomena which I have not quite mastered, but which were possibly due to this. He got a considerable number of transits of the Sun and planet over the wires of the instrument, and of the cusps at egress and observed the internal contact then. Unfortunately the chronograph had chosen *that precise minute* for stopping, and the native who saw it went and told him. Thinking he might save the termination of the Janssen slide, he left his place without *recording* the time by his dial, but he recollects the second, which was within two of mine again. He saw a veil of grey, but the time above refers to contact of limbs.

"Captain Waterhouse got 109 photographs of the solar disk, nearly all with wet collodion. A few dry plates were prepared and exposed, but he finally felt no confidence in any dry-plate process, and arranged for wet plates. The Janssen at internal contact at egress is affected by the stoppage of the chronograph I have mentioned. The first ten exposures are the last record on the fillet, which stops just forty seconds before the last contact as observed by me. The seconds are already small, but there can be no question of any exposure to $\frac{1}{4}$ of a second up to this point. The end of the plate depends on Captain Waterhouse's recollection, and a note of the *last* exposure, for it so happens that owing to a native communicating *verbally* a signal he had made by order, Captain Waterhouse stopped the Janssen and restarted it. I hope that I may be able to give the instants within a single second of each picture, but, indeed, I cannot see how any accurate measurements can be made from such hazy pictures. It is partly the fault of the air, but partly of telescopic tremor, and partly that we have never been able to get a really good definition. The wires are *very* sharp, but that does not apply to any Sun-image, and the search after the cause is complicated by an occasional image being fairly sharp in our experiments. We have hardly ever been free from considerable atmospheric tremor, and that may be all that is wrong, but I have had some very fine views of solar spots, without the definition in the photoheliograph being what I had hoped."

Colonel Tennant remarks, in a second letter of the same date as the preceding, that he believes that he has quite unravelled the time of the photographs of the internal contact at egress by Janssen. He was also assisted by Captain Heaviside, R.E., who took charge of the barometer, and of the removal of the paper fillets, and winding them up periodically. He also observed the contacts with the Royal Society telescope by Slater, but his egress was lost with the failure of the chronograph at the internal contact.

*From Captain Tupman's Report, dated Honolulu, December 12, 1874.*

"The sky was absolutely cloudless, a circumstance not altogether in our favour, as the heat of the Sun was terrific. The walls of the huts facing the Sun had become excessively hot, and caused heated currents of air to rise before the object-glasses of the Naylor equatoreal and photoheliograph, producing the phenomenon known as 'boiling' to a great degree.

"Ten minutes before the computed time of external contact, I began to watch the so-called chromosphere shining brightly right across my field. I saw the advancing limb of the planet very distinctly for about a minute of time altogether. The *Nautical Almanac* time seemed to be about two minutes too early. When *Venus* was about halfway across the chromosphere, I gave the signal to begin the first Janssen plate. External contact passed, I left the $4\frac{1}{2}$-inch telescope to Mr. Nichol, and went to the 6-inch, and assisted Mr. Scobell Clapp. I observed the planet until my eye was fatigued, and the Sun too low for reliable measures. With a dark glass *Venus* was distinct to the otherwise naked eye.

"Mr. Nichol made a fine series of micrometer measures. He withdrew his micrometer fully 30 seconds before I did; and seeing, as he thought, that contact was passed, recorded no later times. I am not at all surprised, for there was nothing sudden to note, and the complete submergence was so gradual, anyone might have recorded ten seconds before I did, and have been probably quite as accurate. My first impression was such an observation could not possess any value. It was something similar in principle to having to decide where the Zodiacal Light terminates! bearing in mind, of course, that we expected to get the contact within a second or so of time.

"The complete disk of *Venus* was seen at Waimea twelve minutes, at Honolulu five minutes before internal contact. This is a new and very interesting feature in the transit of an inferior planet.

"Lieutenant Ramsden exposed the two Janssen slides exactly at the right moment. Most unfortunately he pointed the instrument a few seconds of arc too much on one side of *Venus*. Twelve plates were exposed between the contacts, and fifty afterwards. The boiling of the limb in those I have seen is excessive.

"The spectroscope was adjusted carefully at 1 P.M., after the comparison of the clocks and chronometers. The slit was open about ·0016 of an inch, possibly a little more. It seemed to cover 4 or 5 seconds of arc, judging from the extent of the hydrogen stratum visible at one time. The prominences were sharply defined, but just at the vertex of the Sun there were no high ones.

"The driving-clock kept the upper jaw of the slit a tangent to the Sun's limb for many minutes together, and thereby preserving a continuous bright C line. The whole of the spectrum was cut off by a diaphragm, except a narrow strip with the C line in the middle of it, so that there was nothing oppressive in the light.

"The first time recorded, $3^h\ 5^m\ 57^s$, by the chronometer was a mistake. I thought the side of a prominence was the advancing limb of *Venus*. At $3^h\ 14^m\ 17^s{\cdot}5$, I thought I saw the upper edge of the red line smoother than before, about exactly on the Sun's vertex. At $3^h\ 14^m\ 38^s$ the curvature was very distinct. I was sure it was *Venus*. At $3^h\ 14^m\ 47^s$ I called time, because I found it very difficult any longer to see the C line bright between *Venus* and the Sun's limb, which latter I could bring to the edge of the slit by the slightest touch of the finger. At $3^h\ 14^m\ 56^s$ I imagined the line quite severed. At $3^h\ 15^m\ 15^s$ there was a long black division, the C line bright on either side and the Sun just flashing in, and I felt sure the external contact was past.

"I then withdrew the spectroscope, and left the $4\frac{1}{2}$-inch equatoreal to Mr. Nichol, and, going quickly to the 6-inch, put in the double-image micrometer and made eight measures of the distance between the obtuse cusps made by the advancing planet. I did this more by way of doing something than for any use the measures might be afterwards. During these measures the planet was not quite in focus, as I discovered afterwards.

"I removed the micrometer, put in the negative eyepiece (the only one used, with neutral-tint dark head), scrutinised the planet without perceiving anything worth recording, showed it to Mr. Clapp, and then rested awhile. It never occurred to me to look for a faint extension of the Sun's light beyond the ordinary limb. I had the light intentionally much reduced, as I knew the observation would be the more certain.

"When *Venus* was somewhat more than half on, I replaced the micrometer and measured her diameter, in a direction parallel with the cusps, five times on one side of zero, six times on the other, then five times on the first side. *Venus* was very agitated during these measures, but at intervals her limb was very sharp."

*From a letter addressed by Captain Tupman to Captain R. P. Cator, of H.M.S. Scout, dated December* 9, 1874.

"The sky was cloudless the whole afternoon, and the atmospheric conditions generally favourable. I observed the external contact of the planet with the Sun's limb in the spectroscope at $3^h\ 7^m\ 1^s$ local mean time. Mr. Noble thought he caught it at $3^h\ 7^m\ 3^s$. During the passage of the planet across the limb of the Sun 40 micrometer measures were taken by Mr. Nichol and myself.

" The important phase of the phenomenon of internal contact presented wholly unexpected appearances, totally unlike what we had been led to anticipate. For many minutes before contact a faint light was seen behind *Venus*, beyond the Sun's limb, rendering the complete circle of her disk visible. From that time until the establishment of complete contact no sudden or definite phase could be seized upon, such as the practice with the working model induced us to watch for. The eye-observations of contact, therefore, do not present results of extreme value. As they stand, the following are the times noted—contact certainly established—local mean solar times :—

| | h | m | s |
|---|---|---|---|
| Mr. Noble . . . . . | 3 | 35 | 54·4 |
| Captain Tupman . . . . | 3 | 35 | 55·7 |

" Owing to the unexpected appearance of light beyond *Venus*, Mr. Nichol recorded a time 47 seconds earlier. After the contact, 81 measured distances of the limbs were obtained with the micrometers in the course of 27 minutes.

" In the photographic department a Janssen slide was exposed at external contact at intervals of five seconds. Twelve square Sun-pictures were taken between the contacts. Janssen's slide was exposed at intervals of one second at internal contact, and fifty square plates afterwards. All these plates, judging from those now developed, are first-rate except the second Janssen, on which, owing to defective pointing, the planet is everywhere cut in half at the side of the picture. This is the more to be regretted as the exposure was given at exactly the right time, and it is exceedingly doubtful if such fine atmospheric conditions were obtained at any other photographic station.

" I beg personally to return you my best thanks for the invaluable and courteous assistance you have rendered to the Expedition from the first."

*From Lieutenant Noble's Report, dated Honolulu, December 9, 1874.*

" As the time for external contact approached, I observed a slight notch on the vertex of the Sun, and when fully satisfied that *Venus* had entered on the Sun, I called out ' Stop ' to Lieutenant Shakespear, who had been watching the clock for four or five minutes. I estimated the time of external contact as $2^m\ 30^s$ before that recorded ; a note was entered to that effect in the memorandum-book. I then left the telescope, and took only casual glances as the planet advanced on the Sun, till within about $10^m$ of the time of internal contact, when I kept the instrument pointed on the Sun's limb. Whilst thus watching, I was astonished to see most distinctly the disk of the planet

complete, and immediately asked Lieutenant Shakespear what time remained before contact; he said a little over $5^m$. There was an understanding between us about the *Nautical Almanac* time being $2^m$ out from the external contact. The Sun's limb was very steady, and the planet was quite circular, with a blueish rim round it.

"The first time recorded at internal contact ($20^h\ 45^m\ 43^s$) is that when the cusps had apparently joined. There was no black-drop—no ligament, but a rough dark shade, which gradually faded off to a thin tint, corresponding to the phenomenon I had observed in the model. This, instead of being nearly instantaneous, as the model generally showed, extended over about $20^s$. The thin tint is that recorded as the second time ($20^h\ 46^m\ 2^s$) at internal contact."

*From Mr. Nichol's Report, dated Honolulu, December* 9, 1874.

"The first time recorded was when I perceived a definite indentation on the upper limb of the Sun, and the contact must, from its size, have occurred $30^s$ to $1^m$ before that time. I then changed places with Captain Tupman, took his $4\frac{1}{2}$-inch telescope; the planet was then put into the middle of the field, the telescope into accurate focus and equal light intensity. Twelve observations for diameter were then taken with the double-image micrometer, as the planet then appeared to be fully half way on the Sun.

"Seventeen observations of cusps were taken, and the definition of the extremities of the cusps was good, and no difficulty was found by me in just getting them to touch.

"The telescope was slightly disturbed in inserting the negative eyepiece (power about 130) but that did not prevent me from getting it brought into position and sharply focussed in $32^s$ after the last reading of micrometer, when, to my astonishment, I saw a completion of light round the planet perfectly distinct, and such as I should have said, from previous model practice, was immediately after contact. I got this time recorded as the first observation of contact by seeing the continuous narrow band of light. I remained looking at it for about two minutes, but could see no instantaneous phenomenon of contact, nor black-drop.

"From what I learn from others who continued to observe during the whole phenomenon with the same eyepiece, I feel inclined to think that that thin line of light which I observed on changing the eyepieces must have been due to light from the Sun's corona.

"No light of the kind was visible in the double-image micrometer, and I regret that it was changed, since otherwise I think a very good contact would have been obtained by it."

*From Professor Forbes' Report, dated Kailua, Owhyhee, December* 9, 1874.

"Just before external contact the Sun was clear. Clouds covered the Sun during external contact. They cleared off until it was time to begin measuring cusps. The Sun was then obscured until after contact. I obtained about ten measures of the distances of limbs, besides measures of the planet's diameter."

*From Mr. Johnson's Report, dated Waimea, Atooi, December* 9, 1874.

"My observation was $14^{s}\cdot9$ later than Mr. Dunn's. Twelve minutes before the meeting of the cusps, the entire of *Venus* was distinctly visible, a faint ring of light beginning to appear round the edge of the Sun. At $4^{m}\ 30^{s}$ later the ring of light was very plain; no black-drop. The weather was beautiful for the transit; not the faintest cloud or mist appeared."

The Rev. Robert Dunn, who observed at the same station, remarks that before internal contact he saw the light round the planet and was under the impression that he was deceiving himself through wishing to see the whole of the disk.

*From Major Palmer's Report on the arrangements for observing the Transit in New Zealand, dated Burnham, Christchurch, New Zealand, November* 22, 1874.

The loss of observations from this important station, where the arrangements had been so admirably made by Major Palmer, R.E., is a great misfortune. An extract from his report of progress to the Astronomer Royal will, notwithstanding that the labour has been unrewarded by success, be read with interest. Major Palmer remarks:—"Besides the regular work of the Observatory here, my chief task has been the organisation of subsidiary stations, and arrangements for giving them Burnham time on December 9. I shall have five observers co-operating with me, three in the North Island, two in this island. The stations are, Grahamstown, Mr. Severn; Auckland, Mr. Heall; Wellington Observatory, Archdeacon Stock and Dr. Hector; Caversham (Dunedin), Messrs. Thomson and McKerrow; and Nascby (Otago), Lieutenant Crawford, R.N., and Captain Williams, of the *Merope*. The first four stations have 4-inch telescopes, transit instruments portable or otherwise, with chronometers or clocks. At Grahamstown there is a $10\frac{1}{2}$-feet reflector, 'front view,' 11-inches aperture, on which its owner, Mr. Severn, has

been at work for six years, expressly to observe the Transit of *Venus*.

"I am now in telegraphic connection with Professor Peters at Queenstown, and we are arranging a plan for systematic comparison of our clocks by galvanic signals for several nights together. I hope to begin this week.

"The French ship-of-war *Vire*, Commandant Jaquemart, attending upon the French party under M. Bouquet de la Grye, at Campbell Island, has received time-signals twice from my transit clock; first, on November 4, at Port Lyttelton, and secondly, on November 16, at Port Chalmers, immediately prior to sailing for Campbell Island, which she would reach in two or three days. Thus she obtained a good rate for her chronometers and good time to take away with her. The signals were in each case received and sent with a good chronometer, brought on shore for the purpose, and compared with the other chronometers on board the ship immediately before and after.

"I have applied to the senior Naval Officer, Commodore Goodenough, now at Sydney, for a man-of-war to carry out a chronometric expedition to the three island stations—Chatham Islands, (American), Campbell Island (France), and the Auckland Islands (Germany)—as soon as practicable. It is possible this plan may not entirely succeed, from want of time, for I hear that it is likely the two first-named (of the Germans I can get no information) will break up directly after the transit. But this information (which was hardly to be anticipated) only reached me ten days ago; besides which there has been no man-of-war in New Zealand waters since the departure of the *Blanche* more than a month ago; and the Commodore has but quite lately (within ten days) returned from the Fiji Islands. The failure, therefore, if any, will, on our part, have been unavoidable.

"I have, in former letters, referred to the valuable help in various ways which this Expedition has received from the General and Provincial Governments; and in respect of this subject, I lately received a letter from the Public Works Minister of the General Government, informing me that they were prepared to pay the entire cost of the building works at this Observatory, the telegraphic connections, and the formation of the subsidiary stations, that of Naseby only excepted. This liberal dealing will a good deal relieve the cost of the Expedition."

*From a letter of Mr. Ellery, dated Melbourne Observatory, Dec.* 30, 1874.

"We had very fair success with the Transit of *Venus*, and observed internal contacts at ingress and egress, the first under exceptionally favourable circumstances. One or other of the phases was also observed at each of our three subsidiary stations.

The times were somewhat later for ingress and earlier for egress than those given in the ephemeris. I have forwarded detail notes of our Victorian observations to the Royal Astronomical Society, with rough diagrams. Our photographic work at the Transit, I fear, is not a great success; however, we obtained several photographs by Captain Abney's dry process, both with the Janssen and other plate holder. I have sent sample prints to Mr. De La Rue. . . . . We are expecting some of the Southern Expedition astronomers here in February. The Americans are anxious to bring about a conference in Melbourne at that time, to compare notes, &c. In Tasmania they were only partially successful. Professor Harkness obtained valuable photographs at Hobart Town, but no contact observations, I believe. Captain Raymond, at Campbell Town (another Tasmanian station), was even less successful. All the New Zealand parties were comparatively unsuccessful, the American party in the south being the most fortunate, The German party at the Auckland Islands had much better fortune than was anticipated; for, although the earlier phases were lost, the sky became clear soon after ingress, and a fine set of photographs and egress phases were satisfactorily obtained. Grave fears were entertained of the safety of this party, as they had not made their projected chronometer trips between the Islands and the Bluff, New Zealand, prior to the Transit, so that the U.S. frigate *Swatara* went down to look for them on their way to the Chatham Islands. In the meantime the Germans made a trip to the Bluff, and reported all well. Mr. Todd, at Adelaide, observed the egress satisfactorily; and in New South Wales they had very fine weather, and successfully observed the whole transit. We have arranged about telegraph determination of difference of longitude between Hobart Town and here. Professor Harkness came over to Melbourne to settle preliminaries. The return operation is deferred till the *Swatara's* return to Hobart Town in January."

On the return of the members of the different Expeditions, British and foreign, the next important step will be the uniform Reduction of the Observations on some well-arranged plan. An arrangement of this kind will be absolutely necessary if all the observations of the transit are to be employed in deducing the most reliable value of the solar parallax, which may strictly be an international one. The subject has already been occupying the attention of the Astronomer Royal, who, at the December meeting, explained briefly what, in his opinion, is the best mode of procedure: taking into consideration that different nations and observers are concerned in the observations; that different theoretical views have influenced the choice of stations and planned the observations; that different classes of instruments have been employed, and that the observers have had their attention directed to different ideas of the phases of the pheno-

menon to be observed. The Astronomer Royal proposes a form of reduction which will include in one group all the different methods of observation, such as those made by the eye only, by photographic record, by measures made with the heliometer or double-image micrometer, and by all methods at all the stations. In his paper communicated to the Society he says:—"In this form I hope the whole body of observations will be reduced, at least in the first instance. It possesses this great value amongst others, that it enables us at once to point out a faulty observation, which otherwise might lurk undiscovered, but producing a baneful effect on the conclusions. Those investigators, however, who desire to ascertain the inferences properly deducible from limited classes of observations will find that this method gives them every facility. The equations to be used are ready to hand, and it is only necessary to separate them from the others. Still I hope that in the final reductions the whole mass of observations will be used in one group. Every individual observation will then have an influence proportional to its merit; and reason, as well as formula, leads us to think that the best final result will thus be obtained."

### *The Total Eclipse of the Sun, April* 16, 1874.

Although this important eclipse was not visible in a region easily accessible to European Astronomers, yet it was not permitted to pass away unobserved. Only one series of observations, however, has been made, and that by Mr. Stone, who was fortunately located in a district where the weather was all that could be desired. The spot selected by Mr. Stone was Klipfontein, in Namaqualand, South Africa, situated about 55 miles from the sea, and 20 miles from the central line of shadow. In many other districts on the shadow-path, clouds prevented any details of the phenomena visible during totality from being observed. At Port Nolloth on the western coast, and at Port Elizabeth and Graham's Town on the south-eastern coast of the colony, very little of the eclipse was seen.

Mr. Stone's observations are of great importance, though he was prevented from doing altogether what he wished, owing to the limited number of instruments at his disposal. He would have been glad to have had a telescope equatoreally mounted, furnished with a driving-clock, but such an instrument could not be obtained at the Cape. In his dilemma, Mr. Stone made an application to the Council for assistance, but unfortunately they had no available equatoreal suitable for the purpose, and some of the spectroscopes which had been lent to former eclipse Expeditions have not yet been returned to the Society. Mr. Stone's instrumental equipment, therefore, was limited principally to a 4-inch telescope, mounted as an altazimuth, which he had

borrowed from Mr. Solomon, of Cape Town. To this instrument he attached a spectroscope with two dense flint prisms of 60°, by which he was able to obtain a fair amount of dispersion.

The details of the observations have been forwarded to the Society, accompanied by several sketches of the corona made by Mr. and Miss Hall, of Klipfontein, and others. An account communicated by Mr. Stone to the Astronomer Royal appeared in the *Monthly Notices* for June, and the detailed account, lately received, will shortly be published. In the meantime, the Council are glad to give in this Report an extract describing the observations. During the totality not a cloud was visible, and the sight to the naked eye, during the few moments Mr. Stone could spare from his work, was grand and impressive beyond conception.

The following is extracted verbatim from Mr. Stone's remarks:—"First, with respect to the existence of additional absorption lines in the Sun's spectrum near the Moon's limb, I examined this point with considerable care during the partial phase, but I could not detect the presence of any additional lines, nor any sensible change in the appearance of any of the Fraunhofer lines in the spectrum near the Moon's limb from that presented at considerable distances from it. I consider that these observations afford another proof that there does not exist any sensible atmosphere around the Moon, and that we are warranted in assuming that no sensible refraction of the rays of light from the Sun or corona can take place at the Moon, and that no modification of the visible corona can be attributed to any such cause. As the time of totality approached, I rested my eye for some time. The diminishing segment of the Sun's disk was then brought into the centre of the slit, and carefully kept there until the instant of totality. At that instant, and for some little time afterwards, the field appeared to be full of bright lines of very different lengths. My impression was that all the Fraunhofer lines were seen reversed, but this is, of course, only an impression. I can only state, as a matter of fact, that a very large number indeed of bright lines were seen. I had hardly recovered from the surprise at the sight presented, and begun to attempt to count the lines, when the greatest portion of them vanished, and I saw little more than a hydrogen spectrum. It is difficult for me to form any correct idea of the time during which the general reversion, or what I assumed to be the general reversion, of the Fraunhofer lines lasted, but I should hardly consider that it could have been longer than a second. From the shortness of many of the lines it would have been quite impossible to have seen their reversion unless the slit had been very perfectly adjusted parallel to the tangent to the Sun's limb, at the point of last appearance of the Sun."

About this time, not desiring to examine the spectrum of the prominences, Mr. Stone gave a hasty glance at the eclipse to see whether the brightness of the outer corona appeared

sufficient for the work he intended to do. This was the only opportunity he had of witnessing the eclipse during the totality, except through the spectroscope. Several stars were seen, and *Venus* was a conspicuous object near the corona. "My first impression was," Mr. Stone remarks, "that the corona consisted entirely of a pink-coloured irregular ring. The rose-coloured prominences were seen clearly, and were to me of a much deeper red than the inner corona. When looking carefully for the parts beyond this inner corona, or as I at the time regarded it, the chromosphere, I saw most distinctly, and without any difficulty when attention was fixed upon it, the branches of the outer corona marked C and B in the composite picture.

"On sweeping across the inner corona, the hydrogen lines were seen extended across the slit, a line somewhere in the green, and two or more much fainter lines of less refrangibility than the green line were also seen. There was also a pretty bright spectrum which appeared continuous, but the spectroscope was swept rather rapidly over the inner corona, and I do not feel myself in a position to speak with any great certainty of its spectrum. When the telescope had been fairly directed to the middle of the branch B, the spectrum was carefully examined. I could, in the spectrum of this part of the corona, only distinguish one bright line. If there were any more present they were so much fainter than the line referred to that I could not, after a careful examination, see them. But, besides the one bright line, there were certainly dark or absorption lines present in the spectrum, although they were seen with great difficulty.

"As soon as the totality was over the micrometer was read, and a bisection of the line E and the nearest of the *b* lines made to prevent any possibility of mistake. The bright line turned out to be line 1474 of Kirchhoff's scale. The wave-length from my observations was 5,312, which appears to differ about the breadth of the D lines apart from the value determined for the line seen in the spectrum of the corona by Young."

The general results which Mr. Stone considers he has obtained from the observations are summarised as follow:—

"1. A confirmation of Young's observations of the general, or nearly general, reversion of Fraunhofer's lines in the spectrum of the corona near the photosphere. 2. A spectroscopic examination of the outer corona, in contra-distinction to the inner corona, carried to the extent of rather more than a degree from the Sun's centre, which has proved that the spectrum of the outer corona consists of a linear spectrum of one bright line, either exclusively or sensibly, whose wave-length is 5,312, and of an ordinary sunlight spectrum with absorption lines. The spectrum of the outer corona has been shown to fade gradually away as the extreme visible limit of the corona is approached, and not to disappear sharply as if the extreme limit of the corona had been reached. 3. This spectroscopic examination of the outer corona, combined with the unchanged character of its

principal features as seen at Namaqualand, Griqualand, and Basutoland, at intervals of absolute time extending to $10^m$, and at distances of more than 500 miles, proves, I venture to think, the solar origin and cosmical character of the outer corona. The want of coincidence in the positions of the general extensions of the inner corona with the main branches of the outer corona is an additional argument against the atmospheric origin of the outer corona. 4. A comparison of the drawing by Mr. Hall, made at Namaqualand, and the photographs obtained in 1869 and 1871 shows the permanent character of the contraction of the inner corona in a direction parallel to, or nearly parallel to, the Sun's axis of rotation. The strongly marked character of the contraction of the outer corona in the same direction, as seen in the Eclipse of 1874, may not improbably ultimately lead to a similar inference in the case of the outer corona also."

*Discovery of Minor Planets.*

Eight new planets have been discovered since the last anniversary: four by M. Palisa, and one each by Dr. C. H. F. Peters, Mr. Watson, M. Perrotin, and M. Paul Henry:—

(135) *Hertha*, discovered at the Litchfield Observatory, Clinton, New York, by Dr. C. H. F. Peters, on February 18, 1874. This is Dr. Peters's twentieth planet.

(136) *Austria*, discovered by M. Palisa, at Pola, on March 18, 1874.

(137) *Melibœa*, discovered by M. Palisa, at Pola, on April 21, 1874.

(138) *Tolosa*, discovered by M. Perrotin, at Toulouse, on May 19, 1874.

(139) , discovered by Mr. Watson, at Peking, on the evening of October 10, 1874. Mr. Watson was stationed at Peking as one of the observers attached to the American Expedition for the observation of the Transit of *Venus*. This is Mr. Watson's sixteenth planet.

(140) *Siwa*, discovered by M. Palisa, at Pola, on October 13, 1874.

(141) , discovered by M. Paul Henry, at the Observatory of Paris, on January 13, 1875.

(142) , discovered by M. Palisa, at Pola, on January 28, 1875.

*Discovery of Comets.*

Eight comets have been detected during the past year. The dates of discovery and the names of the discoverers are as follow:—

Comet I 1874, discovered at Strasburg, by Dr. Winnecke, in the night of February 20–21.

Comet II 1874, discovered also by Dr. Winnecke at Strasburg, on April 11.

Comet III 1874, which became so splendid an object in the northern sky in June and July, was first observed at Marseilles by M. Coggia on April 17.

Comet IV 1874, discovered by M. Borrelly at Marseilles on July 25.

Comet V 1874, discovered by M. Coggia at Marseilles on August 19.

Comet VI 1874, discovered by M. Borrelly at Marseilles on December 6.

Comet I 1875 (Winnecke's periodical comet) was detected by M. Borrelly, at Marseilles, on the morning of February 2, with the aid of M. Oppolzer's ephemeris in the *Astronomische Nachrichten*, No. 2016. The comet was faint with a diffused appearance. Encke's periodical Comet has also been detected at the Marseilles Observatory.

These comets, except Comet III, were strictly telescopic, and observations of some of them have been made by several observers, but they do not appear to have been successfully followed for any length of time. Comet VI was observed by Mr. Hind and Dr. Winnecke soon after receiving telegraphic notification of its discovery, but the generally cloudy weather has interfered very much with the observation of faint objects. Notes on the appearance of Comet III (Coggia's) have been given in the *Monthly Notices* by Mr. Christie, Mr. Ranyard, and Messrs. Wilson and Seabroke, and also a series of sketches of the nucleus drawn by Mr. John Plummer. This comet was well observed both in the northern and southern hemispheres.

A daily ephemeris of Encke's Comet, calculated for Berlin noon by Dr. von Asten, of Pulkowa, has been circulated. It extends from the beginning of 1875 to August 12, and will doubtless be of great service to those who may feel desirous to look for the comet. From a comparison with the Marseilles observations, the error of the ephemeris appears to be small.

*Schiaparelli's Observations of Comet III* 1862.

The careful observations made by Professor Schiaparelli of Comet III 1862, which, among the large comets, possesses a

peculiar interest from its connection with the August meteors (the *Perseids*), have been lately published, the delay having been occasioned by the difficulty of reproducing faithfully the original drawings, which have now been drawn on stone by Signor Tempel of the Milan Observatory. Prof. Schiaparelli, in his *Memoir*, first gives the original observations, and then discusses them under various heads. The apparent brightness of the coma increased from 6 mag. on July 24, to 1·7 mag. on August 31, and the intrinsic brightness, calculated by the usual formula, $\frac{1}{r^2 \Delta^2}$, also increased from 0·210 to 1·017 within the same period, but not uniformly; increasing for ten days, then remaining stationary for a like period, after which there was again an increase for ten days, followed by a second stationary period; these changes being unaccompanied by any marked variation in the size of the head. Corresponding to the increase in brightness of the head, there was a marked decrease in the brightness of the nucleus, which could not, Signor Schiaparelli considers, have exceeded 350 miles in diameter when nearest to us, from which he concludes that its density must then have been considerable, as it alone contained the materials for the coma and tail in all succeeding apparitions of this comet. The appearance of the luminous jets is then discussed, and is connected with a general want of symmetry in the head of the comet, the left side of which (supposing the tail to be below the head) was more developed, so that the comet resembled a stick with a knob on one side. The most remarkable feature in this comet was the large inclination of the tails (of which there were three on August 21) to the plane of the orbit, a fact which was established by the circumstance that the apparent angle between the tail and the prolongation of the radius vector did not change sensibly on the passage of the Earth through the plane of the orbit on August 10. The lateral deviation of the tail, which was very considerable, Prof. Schiaparelli refers to an explosive force from the left of the nucleus, from the effect of which the particles projected from the head would, under the action of a repulsive force from the Sun, describe parabolas, having the head as vertex and the radius vector as axis, the tail being curved back till, near its extremity, it became parallel to the radius vector. This would require the nucleus (which was apparently unsymmetrical) to preserve a nearly constant direction in space, which the author considers might result either from a polar force residing in the Sun, or from the absence of rotation of the nucleus. Another important conclusion drawn by Signor Schiaparelli is that the particles of the tail exercise a mutual repulsion on each other, causing the anterior boundary to curve forward till it cuts the prolongation of the radius vector, the axis of the parabolas which would be described by the particles of the tail if only under the Sun's repulsive force.

*Fundamental Determination of the Longitude of Egypt.*

The selection of Cairo, and other places in Egypt, as positions from which to observe the egress in the late Transit of *Venus*, rendered necessary an accurate determination of their longitudes. For other British stations it was found necessary to depend on lunar methods; but the existence of telegraphic communication between England and Alexandria, by the submarine cables of the Eastern Telegraph Company, offered such facilities for determining the longitude of the Egyptian stations by the transmission of galvanic signals, that it seemed desirable to endeavour to ascertain the longitude in this way. Application having been made by the Astronomer Royal to the authorities of the Eastern Telegraph Company for permission to use their wires, every facility was offered towards the promotion of the undertaking, for which special thanks are due to John Pender, Esq., M.P., Chairman of the Company, and to the Directors, as well as to the Managing Director, Sir James Anderson. The distance from Porthcurno (the telegraph station of the Company in Cornwall) to Alexandria is so great—about 3,180 miles by the telegraph line—that some doubt was at first felt as regards the possibility of effecting the necessary exchange of signals with sufficient accuracy. There were various objections to the establishment of an intermediate station, and it was, after some consideration of the matter, finally decided that, if signals could be exchanged between Porthcurno and Alexandria direct, a telegraphic determination of longitude should be attempted. Consequently, on two different occasions during the summer of last year, preliminary experiments were made at Porthcurno, under the direction of Captain Browne (who commanded the Egyptian Expedition), which resulted in showing that it was quite possible to observe with accuracy signals passed through the whole length of the line. On his arrival in Egypt Captain Browne selected a position on Mokattam Heights for his principal observing station, and it became necessary to erect, as soon as possible, a special telegraph line to connect it with the Cairo telegraph office. This service, among others, His Highness the Khedive expressed his wish to carry out, and his engineers completed the work in sufficient time for exchange of signals on November 14. The cable could be spared from its ordinary work only late on Saturday night and on Sunday evening, and signals were accordingly exchanged on November 14, 15, 21, and 22. The weather was particularly favourable for obtaining the necessary star transits at Greenwich, Alexandria, and Cairo, although on November 21, at Cairo, the observations were made with great difficulty on account of the existence of violent wind. On each evening signals were exchanged between Greenwich and Porthcurno, between Porthcurno and Alexandria, and between Alexandria and Cairo; three exchanges

being unavoidably involved in each night's work. Mr. Criswick operated at Greenwich; Messrs. Ellis and Hunter were stationed at Porthcurno and Alexandria respectively; and Captain Browne was at Cairo. Signals given from one station at seconds of a sidereal clock or chronometer were observed at the other station by a solar chronometer, and signals given by a solar chronometer were observed by a sidereal clock or chronometer. The extreme attention given throughout by the officers of the Eastern Telegraph Company tended greatly to ensure the successful result obtained. Mr. Bull (the superintendent at Porthcurno), indeed, specially prepared instruments for use at Porthcurno and Alexandria for record of the cable signals. The officers of the Post Office Telegraphs, under Mr. Eaton, also gave every attention as regards the land communication on the English side. On each night the cable signals were observed in two ways: First, by noting the *start* of the beam of light, both when the circuit was "made" and "broken" at the other station; and secondly, by observing (as suggested by Mr. C. F. Varley) the transit of the beam, after break of circuit only, over the central point of its excursion. The observations have since been completely reduced, excepting that some corrections for personal equation have yet to be applied. Uncorrected for personal equation, the concluded seconds of longitude on the four nights, for the first-mentioned method of observing, are $6^s{\cdot}59$, $6^s{\cdot}54$, $6^s{\cdot}55$, and $6^s{\cdot}48$ respectively, and for the second method, $6^s{\cdot}55$, $6^s{\cdot}66$, $6^s{\cdot}67$, and $6^s{\cdot}63$ respectively; the concluded longitude of the station on Mokattam Heights, near Cairo, being $2^h\ 5^m\ 6^s{\cdot}58$, as determined from 956 cable signals.

As deduced from the observations of the *start* of the beam of light, the whole cable retardation (or the difference between the longitude resulting from the signals given from Porthcurno and that resulting from the signals given from Alexandria) $=2^s{\cdot}6$.

The separate values of longitude for the different nights agree much better than might have been expected, and the resulting longitude, independently of its use in the more immediate work for which it was undertaken, will form a fundamental determination for the future reckoning of longitudes in that part of the world.

### *Telegraphic Determinations of Longitude in Switzerland.*

The series of telegraphic longitudes determined under the auspices of the "Commission Géodésique Suisse," which has been already noticed in preceding Reports, has been continued, and the results of the observations made for connecting the important stations of Milan, Simplon, and Neuchâtel, have been published. In carrying out the arrangements for this series of longitudes more difficulties were experienced than in all the previous

operations of the kind undertaken by the Commission in Switzerland. Considerable delay took place, first by the illness of M. Hirsch and two of the observers, and secondly, on account of the weakness of the galvanic currents, arising in part from the great distances between the stations, but principally from the defective insulation of the telegraph wires. The depreciation in the strength of the current on its arrival at Neuchâtel from Milan was very great, and whereas the deflexion of the needle of the galvanometer at the latter station was 35°, the current arrived at Neuchâtel so weakened that the deflexion of the needle was only 11°. These and other difficulties were ultimately overcome, and the final differences of longitude between the three stations have been determined most satisfactorily. The definitive values are:—

| | m | s | | s |
|---|---|---|---|---|
| Milan—Simplon = | 4 | 39·238 | ± | 0·013 |
| Simplon—Neuchâtel = | 4 | 16·824 | ± | 0·016 |
| Milan—Neuchâtel = | 8 | 56·062 | ± | 0·016 |

The relative personal equations of the observers was determined before and after the operations, by the method of comparison of transits of both natural and artificial stars, and the large number of comparisons has given sufficient data for the separate personal equations for the six observers who took part in the observations to be determined with great exactness. It was resolved, at the meeting of the Commission held at Neuchâtel in May last, to organise a plan of operations having for its object the connection of the Swiss Observatories with the Observatory of Paris, so that a simultaneous determination of the differences of longitude between Paris, Geneva, Neuchâtel, and Lyons may be effected by the same observers, under the same general arrangements which have been so successfully carried out in this very important series of geodetical operations.

### *First Melbourne General Catalogue of* 1,227 *Stars.*

A very important general Star Catalogue has just been received from the Melbourne Observatory. It has been prepared under the direction of Mr. Ellery, but more immediately by Mr. E. J. White, the principal assistant, and it is a valuable record of about seven years of steady observation with the transit circle. The work appears to be very carefully printed, the typography is good, and it has passed through the press in a manner most creditable to the local printer. The Catalogue contains the mean places of 1,227 stars, for the epoch of 1870, January 1, determined from the observations made at Melbourne from the middle of the year 1863 to 1870. The reduced results for the separate years from which the mean places in the Catalogue are

compiled, are published in the Volumes II. to IV. of the *Melbourne Observations*. The separate columns are arranged conveniently for reference, and the type is very similar to that used in the Greenwich 7-year Catalogue for 1864. The observed magnitudes of the stars are inserted, and also the number of estimations on which the printed value depends. The right ascensions and north polar distances are deduced from seldom less than three observations in both elements, while the larger stars, and those used for the determination of clock-error, &c., have been more frequently observed. The logs $a$, $b$, $c$, $d$, and $a'$, $b'$, $c'$, $d'$, for the computation of apparent place by Bessel's formulæ, as arranged by Baily, are given for each star; a convenience to the computer which ought never to be omitted in any star catalogue intended to be used. The corresponding reference numbers to the Catalogues of Lacaille, Piazzi, Brisbane, and Johnson, are also given.

The want of reliable places of the southern stars, comparable with those deduced from observations made at the northern observatories, is now being gradually supplied. When the reductions of the Cape observations are completed and published, under Mr. Stone's vigorous direction, our new southern star catalogues of the Cape and Melbourne Observatories may be utilised to the science by the formation of a combined standard star catalogue for the whole heavens, on the plan of the *British Association Catalogue*, which has ever been a favourite work with the practical astronomer. The materials will be ready in a few years for such a compilation; and it may probably become a question for the Council to consider, at some future time, whether such an important undertaking could be advantageously carried out under the auspices of the Society. Such a catalogue of stars would indeed be a boon to astronomers for a whole generation.

### *Struve's Observations of ζ Cancri.*

A most interesting and valuable paper on the orbit of *ζ Cancri*, by M. Struve, has lately appeared. It contains a general history of the observations of this well-known triple star, with the measures of distance and angular position, made by Sir W. Herschel in 1781, by W. Struve from 1826 to 1836, and by O. Struve almost continuously from 1840 to the present time. The principal star was resolved into two by Sir W. Herschel in 1781, when he observed the angular position to be 3°·47. He afterwards had some doubt of his observations, as he was unable in 1802 to see the stars distinctly separated. J. Herschel and South, in their joint work on double stars, make no mention of the observation of 1781; but in the spring of 1825 South confirmed the duplicity of the principal star at his temporary observatory at Passy, near Paris. W. Struve, in 1826, observing

with the great refractor at Dorpat, easily separated the stars. Their proximity at the commencement of the present century, when they passed the apparent perihelion, gives a possible explanation of the probable cause of the failure of Sir W. Herschel in 1802. The magnitude of the three stars, according to W. Struve is, A = 5·0, B = 5·7, and C = 5·3. They are of a yellow colour, with a slight variation in their intensity. Their proper motion has been found to be nearly the same, and it may be therefore assumed that the three stars are physically connected; the amount of proper motion is, however, not large, only 15″·2 in a century, but this value has been sufficiently established by several concordant determinations.

On an examination of the long series of observations given by M. Struve, it will be at once perceived that the close stars A and B have completed one entire revolution in 59·4 years. The position-angle given by Sir W. Herschel in 1781 may very possibly be in error a few degrees, which would slightly modify the period. In 1826, the annual increase in the position-angle being about five degrees, a probable error of that magnitude may reasonably affect the single observation of Sir W. Herschel. But if a difference of two years or more is found in the period of revolution, it ought not to be solely attributed to the errors of observation. There is, therefore, every reason to believe, or at least to suspect, that the difference is caused by the effects of the attraction exercised by the third star, and M. Struve has already discovered traces of this attraction in his measures of the distance between the close stars A and B.

During the period of M. Struve's observations, the apparent orbit of B around A has been so nearly circular that if there be any ellipticity, it cannot exceed one-tenth. Assuming, therefore, that the orbit is circular, the following elements have been calculated by M. Struve:—

Perihelion passage, 1869·3.

| | |
|---|---|
| Angle of position of perihelion | 199°·0 |
| Excentricity | 0°·353 |
| Semi-axis major | 0″·908 |
| Inclination | 20°·7 |
| Angle of position of ascending node | 109°·0 |
| Mean annual motion | 5°77 |

Period, 62·4 years.

In a diagram, M. Struve represents the positions of the three stars in relation to the optical centre between A and B, which he assumes for his purpose to be either fixed, or carried through space with a uniform motion. He has found that the position-angle of C had changed by about 47°, or 0·5 per annum. But

this angular movement has been by no means uniform, at any rate since 1826; on the contrary, it has alternated in periods of about ten years, being sometimes more rapid, sometimes *nil*, or even retrograde. Moreover, the more rapid angular movements have been always accompanied by a very distinct increase of distance, and the retrograde movements by a corresponding diminution. And these irregularities are too considerable to be entirely attributed to errors of observation; besides, their periodical and concurrent nature clearly point to some physical cause. It is natural to recognise in them the effect of the attraction exercised on C by the two other stars of the system, of which the relative positions, on account of their proximity, change much more rapidly. "Unfortunately," says M. Struve, "analysis does not yet furnish us with the means of resolving the problem of the three bodies in the general condition of the system before us, and any approximation even is rendered almost impossible, from the defect of all knowledge of the relative masses of the three stars. And the circumstance alone that we have adopted, instead of the centre of gravity of the whole system, the optical centre of A and B, may have had an important influence on the figure of the curves representing the motion of C. We may here remark that the angular movement of C would have shown irregularities still more considerable if we had referred the measured positions to the single star A. Our observations indicate the same mutual positions for A and C, at epochs differing by 26 years, from 1835 to 1861, in which interval the mean motion, $-0°{\cdot}5$, resulting from a comparison with Sir W. Herschel's observation, as well as from a mean of our own measures, would have diminished the position-angle by 13 degrees. On the other hand, the distances between A and C have remained nearly constant throughout that period."

M. Struve concludes by calling attention to another remarkable circumstance. The diagrams show that the same deviations from uniform curvature are reproduced in periods approximately of 20 years. In fact, all the observations are sufficiently represented, with only possible residual errors, by assuming

$$P = 155°{\cdot}00 - 0°{\cdot}50\,(T - 1831{\cdot}3) - 3°{\cdot}00 \sin 18°\,(T - 1831{\cdot}3)$$

$$e = 5''{\cdot}50 \qquad + 0''{\cdot}20 \cos 18°\,(T - 1831{\cdot}3).$$

"Remembering that at the distance $5''{\cdot}50$, three degrees correspond to nearly $0''{\cdot}30$ of space, the last terms of these formulæ show that the inequalities indicated admit of a satisfactory explanation, by supposing that the star C, whilst moving in the mean in a uniform orbit about O, the optical centre, describes at the same time a secondary orbit, approximately circular, of $0''{\cdot}3$ radius, in a period of twenty years. Such a secondary orbit might probably be produced if there were another disturbing body, perhaps opaque or less luminous, in the immediate neighbourhood of C."

*The Companion of Procyon.*

In March and April 1874, M. Struve continued his observations of the companion of *Procyon*, although the state of the weather in the spring months was not favourable for such delicate astronomical observations. The former measures were alluded to in the last *Annual Report*. In an oral address, delivered at the meeting of the Society in May 1874, M. Struve gave a detailed account of his observations, from which it appears that he is convinced that the faint object he has observed is in all probability the companion of *Procyon*. After Dr. Auwers had re-determined the orbit of *Procyon*, including in his investigation the observations made before 1874, he seemed still to have some doubt whether the object observed by M. Struve was really the only body disturbing the motion of that star, but he remarked that this doubt would be completely removed if in the observations which might be made in the spring of 1874, the position-angle was found to have increased 9° to 10°. And supposing this object is really the disturbing cause of the irregularities in the proper motion of *Procyon*, its position-angle at the end of March 1874 would be 97°, but that if it is merely optically close to *Procyon*, then the position-angle would be only 84°. The following are the mean distances and position-angles observed by M. Struve in 1873 and 1874 :—

1873, March 28, $d = 12''{\cdot}49$; $P = 90°{\cdot}24$.

1874, April 10, $d = 11''{\cdot}67$; $P = 99°{\cdot}60$.

It is evident from the above numbers that Dr. Auwers' prediction is sensibly verified, and that the amount of change in the position-angle agrees with that mentioned by him. M. Struve considers, therefore, that the identity of this companion is decisively established. He remarks, "I consider that the object I have observed is actually the companion whose existence has been theoretically proved by the calculations of Dr. Auwers, and I hope that the astronomical world will rejoice with me in the triumph thus obtained for the labours of my honoured friend, and through them for our common science. In order to remove any exception that might be taken that the wished-for result had in any degree been itself the cause of the recognition, and thus influenced the measurement of the position of so faint an object, I will just remark that I had not seen the paper of Dr. Auwers since its first receipt last summer, and I had totally forgotten the data of its criterion and the mutual relation of the two stars. I did not again refer to it till after I had succeeded in making the first observation; and the results of that paper were even less present to the mind of my assistant, M. Lindemann, whose younger eye appears generally to have seen the companion even better than mine." M. Struve adds that we must not, however,

forget that other astronomers who are accustomed to the use of large telescopes have failed to see the companion. Observers with the Washington Refractor of 26-inches aperture, an instrument which appears to be credited with a great penetrating power, have not succeeded in detecting it, and this important fact ought not to be overlooked. On the other hand, M. Lindemann, of Pulkowa, and M. Ceraski, of Moscow, appear certainly to have noticed it without being in any way influenced by a previous knowledge of its exact position.

After these observations of M. Struve, and the confirmatory observations of M. Lindemann and M. Ceraski, the evidence is increased in favour of the conclusion that the irregular proper motion of *Procyon* is caused by a companion, or satellite, as pointed out in the investigation of Dr. Auwers, and that this satellite is identical with the object observed by M. Struve.

### *Scintillation of the Stars.*

In the *Bulletins de l'Académie Royale de Belgique*, t. xxxviii., No. 8, M. Montigny has published a second paper on this interesting phenomenon, especially in relation to the numerical frequency of scintillation as compared with the characteristic spectra of certain classes or groups of stars. He appears to show satisfactorily that those stars whose spectra contain numerous dark lines and zones, or bands, scintillate less than those whose spectra exhibit a large number of fine lines, and considerably less than stars whose spectra are especially distinguished by a few principal lines only. Relying completely on Padre Secchi's classification, M. Montigny has observed the numerical frequency of scintillations of forty-one stars, sixteen of which are included in the first type, or those presenting four principal lines in the spectrum; fourteen in the second type, whose spectra are traversed by numerous fine lines; and eleven in the third type, which exhibit the very characteristic dark nebulous zones or bands, and dark lines peculiar to this class. The conclusions to which M. Montigny has arrived are, that *α Lyræ* and *Pollux*, the respective types of the first and second groups, and those stars in each class having similar spectra to them are distinguished by the most frequent scintillations. Taking the mean in each group of the frequency of scintillation, or the number of variations per second in the light of the stars, at an altitude of 30°, he finds that the variations amount in the respective groups to 86, 69, and 56. In the case of *ε Ursæ Majoris*, which stands at the head of the list in the first group, the frequency of scintillation per second amounts to 111, while in the three next stars on the list, *β Ursæ Majoris*, *Procyon*, and *α Lyræ*, the number amounts respectively to 104, 103, and 98. The scintillations of *Castor*, *α Coronæ*, and of *η Ursæ Majoris*, which are at the end of the list in the first group, are respectively

62, 61, and 61, being only little more than one-half as frequently as $\beta$ *Ursæ Majoris*; these stars are also distinguished from the former by having a considerably greater number of lines in the spectrum. In the third group, $\alpha$ *Herculis*, which is the type of its class, is one of those stars whose scintillation is the weakest, not only of those of its own group, but of all others observed by M. Montigny.

An examination of the three tables drawn up by M. Montigny, in which are given the numerical frequency of the scintillation of each star, together with the character of its spectrum, makes it not difficult to observe the coincidences shown by the general agreement between the amount of variations and the peculiar characteristics of the spectra. As an example, M. Montigny remarks specially on the three principal stars in *Andromeda*. He says that "the stars $\alpha$, $\beta$, and $\gamma$, belonging to the same constellation, have been observed under various conditions of temperature. Besides, any influence which the brilliancy of a star might occasionally have on its scintillation would disappear here, as these three stars are about the same magnitude. They are therefore quite comparable with each other, not only in relation to their spectra, but also in the frequency of their scintillations. In the first group, $\alpha$ *Andromedæ* has strongly marked lines, many fine lines, and little red in its spectrum. In the second group, $\gamma$ presents equally fine lines, a tolerably strong ray, and some traces of zones in the most refrangible part of the spectrum. From these indications, we may be permitted to assume that the spaces which separate the rays of these two stars are very probably of equal relative amount, both in the breadth and darkness of these spaces. We can thus explain why the numerical frequency of the scintillations is the same with regard to these two stars. But $\beta$ *Andromedæ* in the third group, in whose spectrum the numerous fine lines are disposed in perfectly distinct zones, forming occasionally the darker portions, scintillates much less than the two others, the variations of colour in $\beta$ having been found to be 57 per second, whilst the corresponding changes in $\alpha$ and $\gamma$ rise to 93. The breadth and relative darkness of the zones in the spectrum of $\beta$ sufficiently explain its weaker scintillation in comparison with the more active scintillation of $\alpha$ and $\gamma$."

M. Montigny remarks further, that from a comparison of the spectra of certain stars observed by Messrs. Huggins and Miller with the numerical frequency of their scintillation, the same general result is found as with Padre Secchi's observations. This independent confirmation he considers is a sufficient proof of the correctness of his researches, and proves beyond doubt that stars which scintillate the least are also those whose spectra contain the most numerous lines, well marked, and sometimes banded together so as to form dark zones. It also clearly shows the intimate relation between the frequency of scintillation of the stars and the composition of their light as exhibited by spectrum analysis.

*Moscow Observations.*

The first volume of observations made at the observatory attached to the University of Moscow has lately been published. It contains all the observations made with the meridian-circle from October 1858 to December 1861, the number of stars observed being very considerable. The work as it stands is an excellent record of the systematic labours of the Moscow observers, and at the same time it is a most valuable contribution to stellar astronomy. The observations are confined almost exclusively to stars, based on a plan of operations suggested by M. Otto Struve, but planned in detail by the late director, M. Schweizer, consisting of an accurate determination of the positions of selected zones of stars of the 7th and 8th magnitudes, in a similar manner to that previously carried out by Professor Argelander in his *Durchmusterung*. The first zone includes all the stars between the equator and 4° North Declination, and their reduced places are contained in this volume; the second zone includes the stars between 4° and 8° North Declination; a limited number only of the reduced results are, however, given, as the observation of stars in the second zone was only commenced in July 1861. Each object has been observed four times and referred to well-known standard stars situated as near as possible to the zone observed, the places of these comparison-stars being taken from the *Nautical Almanac*. The resulting right ascensions and declinations are therefore determined with a considerable amount of accuracy. The large number of 1,147 stars are included in the first zone and 992 in the second. In addition to the zone-observations, some of the planets and Comet II 1861 have been occasionally observed, and the results given in this volume, as well as the places of the comparison-stars observed with the Comets V 1858 and II 1861. Enough is given to show that the primary object of the promoters of this observatory has been successfully carried out, first by the original director, M. Schweizer, and subsequently by his successors, whose activity and zeal have produced so valuable a series of observations. We may fully anticipate that the delay in the publication of the first observations will be confined to this volume, and that a continuation of the series will appear at an early period, when a most valuable combined catalogue, arranged in the order of right ascension, will probably be compiled by the authorities of the observatory, a work which cannot fail to be of great practical benefit to observers. Meanwhile, the Council are glad to acknowledge the appearance of the first volume of the proceedings of a new observatory.

*Schultz's Micrometrical Measures of* 500 *Nebulæ.*

Dr. Herman Schultz, of the Observatory attached to the University of Upsala, has published the first instalment of a most

valuable work, containing the results of the observations of 500 nebulæ, on which he has been employed for many years past. These observations, if an opinion can be formed from the small probable error of the mean results, have never been surpassed in any previous observations of the positions of the nebulæ. The primary object of Dr. Schultz appears to have been the formation of a catalogue of nebulæ whose right ascensions and declinations should be sufficiently exact to serve for a future determination of their proper motions, as he considers that "the question of the proper motion of nebulæ and telescopic clusters is, without doubt, one of the most important in the present state of astronomical science."

The probable amount of the proper motions of the nebulæ has been a subject discussed by astronomers long before Dr. Schultz commenced his observations; but excepting in the positions of a few of the largest of these objects, the mean errors of the observations were, in most cases, too great to determine accurately their annual proper motions. According to Dr. Schultz, the mean uncertainty in Sir W. Herschel's positions amounts to as much as one or two minutes of arc. The probable errors in Sir John Herschel's observations are $1^s$ and $20''$ respectively in right ascension and declination; in D'Arrest's Copenhagen observations $0^s{\cdot}8$ and $18''$; in Laugier's observations of 53 of the brighter nebulæ, and in D'Arrest's Leipzig observations of 200 nebulæ, which were specially observed for the purpose of forming a basis for the determination of their proper motion, the probable error has been reduced to $6''$. But the positions of nebulæ since observed by Auwers, Schmidt, Schönfeld, Vogel, and others have attained even to a far greater accuracy. "Among the general series of observations of this kind," Dr. Schultz remarks, "Schönfeld's famous Mannheim observations of 235 nebulæ are the most comprehensive; and as the probable error in one of Schönfeld's positions appears not to exceed $2''$ or $3''$, and in those of Auwers and Vogel to be still less, it is evident that, by a sufficient multiplication of observations, the determination of positions may be easily carried to a very high degree of accuracy, as indeed my own experience has shown me."

Dr. Schultz's observations were commenced in 1863, and they have been continued, with only occasional interruptions, to the present time. The telescope employed by him was the 13-feet equatoreal. His method of observation consists in determining the differences of right ascension and declination between each nebula and a neighbouring star of sufficient brightness to be observed afterwards on the meridian. The differential co-ordinates in the two elements are observed in right ascension by "eye and ear," using a chronometer, and in declination by measuring the differences with the micrometer-screw, the wires being always illuminated in a dark field. A catalogue of 440 of the comparison-stars, with their mean observed places for January 1, 1865, is given, the greater number of the stars being between the 7th

and 10th magnitudes. A few fainter stars in the immediate vicinity of the nebulæ have also been occasionally compared with them, and those in their turn have again been compared with a star of greater magnitude. The number of single measures on which the results for the nebulæ depend are about 12,000. Dr. Schultz has not yet completed the meridional observation of all his comparison-stars, nor is he yet satisfied with the number of measures of some of the nebulæ, but as his labours have been protracted longer than he had anticipated, he considers it advisable not to defer the publication of what has been already completed, and he remarks, "I confine myself at present to communicating the evening means of the differential co-ordinates observed, and accordingly defer the calculation of definitive means until I have fully completed my own observations and succeeded in obtaining reliable positions for all the stars of comparison employed, so as to be able, at the same time, to give definitively the right ascensions and declinations of the observed objects."

Owing to the difficulties which Dr. Schultz has experienced on account of the generally unfavourable state of the weather at Upsala for observations of such faint objects, he has resolved to confine his attention solely to the 500 nebulæ indiscriminately chosen by him, and thus to consolidate the results already obtained. By this means he hopes to be able ultimately to fix the positions of these nebulæ with sufficient accuracy that they may eventually be employed as the basis of a future determination of their proper motions.

The small probable errors given by Dr. Schultz are very remarkable. Without giving the formula which he employed, it may be stated that the probable errors in the results of one evening have been calculated on two hypotheses, and between the two the true error is supposed to lie:

| Class of Brightness. | Probable Error in R.A. | | Probable Error in Decln. | |
|---|---|---|---|---|
| | 1st Hyp. | 2nd Hyp. | 1st Hyp. | 2nd Hyp. |
| | s | s | ″ | ″ |
| 1 and 2 | 0·092 | 0·073 | 0·79 | 0·63 |
| 3 | 0·096 | 0·072 | 1·03 | 0·78 |
| 4 and 5 | 0·130 | 0·099 | 1·32 | 1·00 |

These numbers give a sufficient character to Dr. Schultz's observations to enable us to form an estimate of the great value which must accrue to astronomy by the publication of such a work when completed. It is, without doubt, one of the most important series of standard observations which has appeared for some years.

A preliminary catalogue of the observed R.A. and N.P.D. of the nebulæ has been presented to the Society, and read at the January meeting.

### *The Extended Nebulæ of Sir J. Herschel's Catalogue.*

Mr. Cleveland Abbe has communicated to the Society a paper, *The very much Extended Nebulæ of Sir John Herschel's General Catalogue*, recently read at a meeting of the American Association for the Advancement of Science. The question is whether there are not planes which have a definite relation to the Nebulæ? such as the planes of the orbit and of the equator in regard to the planets. The author for the time passes by the circular and ordinary elliptical Nebulæ, confining himself to those described in Herschel's *Catalogue* as exceedingly or very much extended, the list of which, amounting in all to 59, is given in a table. In regard to these it is remarked, that if these nebulæ are gaseous and without rotation, their apparent shape is only to be explained by supposing them to be endowed with a motion of translation, to be in fact wisps like comets' tails; if, on the other hand, they be in a scale of rotation, they must be flat rings or disks, or extended or flattened ellipsoids, and it is allowable to consider that the planes of their equators sensibly pass through the position of the observer; similarly, if the nebulous appearance be due to the presence of a lenticular or long-shaped cloud of asteroids, or of meteoric dust, it is possible to make a determination of the planes of the orbits of these bodies.

A trigonometrical formula for calculating the position of the much extended Nebulæ is given in an appended note, the data being the R.A. and N.P.D., and the position-angle of the Nebulæ, regarded as a line, or streak; and the deduced R.A. and N.P.D. of the South Poles of the 59 Nebulæ are given in columns 6 and 7 of the Table; the general conclusion is, that so far as we are able to determine the positions of the planes of rotation among the nebulæ, they do not show any such tendency to agree with each other as is shown in the orbits and equators of the major planets of the solar system; that, on the contrary, they are inclined at all possible angles to each other, but have this remarkable feature, that their mutual nodes cluster about a point in Right Ascension $12^h\,45^m$, and North Declination 60°.

### *Periodicity in the Value of the Sun's Diameter.*

The question whether the Sun's apparent diameter is liable to periodic changes has frequently occupied the attention of astronomers. The subject has been investigated by Von Lindenau, Bessel, and Bianchi, and more recently by Le Verrier, Secchi, Wagner, and Auwers. Lindenau was led to the conclusion, by a discussion of the Greenwich observations from 1750 to 1755, and from 1765 to 1786, that the Sun was an ellipsoid, with a compression of $\frac{1}{279}$ to $\frac{1}{140}$. Bianchi, apparently without being

acquainted with Lindenau's research, found the solar compression $\frac{1}{210}$, but by changing his method of investigation, he obtained values for this quantity varying from $\frac{1}{1925}$ to $\frac{1}{110}$. Bessel, however, considered that a progressive shifting of the wire-frame of the Greenwich transit-instrument would account for the apparent periodicity in the values of the solar diameter. M. Le Verrier, after a careful investigation, came to the conclusion that no real periodic variation in the Sun's diameter existed equal to $0^s{\cdot}02$. More recently, Padre Secchi, considering that the active forces known to be in progress on the surface of the Sun might very possibly produce changes in the volume of the luminous matter composing the chromosphere, announced the result of some researches on which he had been engaged in conjunction with Padre Rosa. He concluded that the variations in the solar diameter were the most apparent when the activity of the forces on the surface of the Sun was greatest; and he considered that, as these variations were frequently more than $3''$ in amount, they could not be accounted for by mere errors of observation. Dr. Auwers, however, who has since thoroughly examined the methods adopted by Padre Secchi, gives as his opinion that the foundations of the theory employed by the latter are so unreliable that, for the present, these results cannot safely have much weight attached to them. Dr. Auwers, anxious to have an independent series of observations as the basis of his examination, obtained from the Observatories of Greenwich, Oxford, Paris, Brussels, Washington, Königsberg, and Neuchâtel, a large number of measures of the solar diameter observed during the same period as those by Padre Secchi at Rome.

With regard to the connection of the value of the Sun's diameter with the solar-spot period, Dr. Auwers has also examined the Greenwich observations of Bradley and Maskelyne, and their assistants, as well as some of those made at Königsberg by Bessel, and at Dorpat by W. Struve; but his result is a negative one. He has also compared the Greenwich solar diameters observed from 1851 to 1870 with Dr. R. Wolf's relative number of the solar-spot conditions, and his conclusions are that, "in the fluctuations of the observed values, both for the horizontal and vertical diameters, and the difference between the two, no dependence upon the variations of the degree of activity, and, therefore, no indication whatever of the reality of these fluctuations, can be perceived."

The evidence thus far seems to negative the existence of any periodical changes in the Sun's diameter of sufficient magnitude to be detected from the ordinary meridional observations of the different limbs of the Sun. This negative evidence is much strengthened by the results of an extensive comparison, by Professors Newcomb and Holden, of the horizontal and vertical diameters deduced from the observations of the Sun at Greenwich and Washington from 1862 to 1870, the transits of the first and second limbs having in this interval been registered on the

chronograph. The total number of observations discussed amount to 1,813 of the horizontal diameter, and 1,826 of the vertical diameter. The principle of the method is given as follows:—"Suppose we have two series of observations of the Sun's diameter made simultaneously at two different observatories, so that each observation of the one series is accompanied by a simultaneous one of the other series. Then, if the outstanding difference between each measure, and the mean of the whole series to which it belongs, is due entirely to the accidental errors of observations, there will be no relation between the differences of the two series. But if a portion of the difference is due to an actual change in the Sun itself, the differences which are positive in the one series will be accompanied by a preponderance of positive differences in the other series. For on the days when the Sun is larger than the average, the probability of finding a positive correction will be more than $\frac{1}{2}$ at each observatory, and hence the probability of an agreement of sign will be greater than $\frac{1}{2}$. If the probability in each case be $\frac{1}{2}+a$, it is easy to see that the probability of an agreement will be $\frac{1}{2}+2a^2$. Our results should, however, depend not on a simple enumeration and comparison of the signs of the residuals, but also on the magnitude of the latter, and we may secure this dependence by taking the algebraic product of each residual of the one series by the corresponding one of the other. If the residuals are purely accidental, the mean value of these products should approximate to zero as the number of observations is increased; while in the case of actual variability, it will approximate to some positive limit."

As many observers were engaged in these observations, it was found necessary to correct the apparent error of the ephemeris diameter for the personal error of the observer, and tables are given containing the adopted errors for each year for each observer, both at Greenwich and Washington. The conclusion to which Professors Newcomb and Holden have arrived seems to be that, whatever apparent variations of a periodic nature in the Sun's diameter occasionally occur, they are probably the result of chance, and that it is clearly shown by their investigation, based upon so large a number of observations, that, if any, only the slightest and uncertain indications of periodicity are exhibited.

*Periodic Errors in the Right Ascensions of Standard Stars.*

Considering that Right Ascensions are liable to systematic errors of three kinds:—1. Those of single period; 2. Those of double period; and 3. Those depending on the declination—Professor Rogers has determined the coefficients of these three errors for a number of modern catalogues by comparing the

Right Ascensions of 32 fundamental stars with those of *Newcomb's Standard Catalogue*, which is presumably free from systematic errors.

The process adopted by Professor Rogers is as follows:— The coefficients of the periodic errors are first provisionally determined for five selected catalogues, and the Right Ascensions corrected for these errors used to determine provisionally the accidental errors of the *Standard Catalogue*. The process is then repeated with the *Standard Catalogue* thus corrected, and more accurate values of the coefficients of the periodic errors obtained for nine selected catalogues, from which the final corrections to *Newcomb's Standard Catalogue* are obtained, and also final values of the coefficients of the periodic errors.

On the results thus obtained Professor Rogers remarks:

I. That, for the observations under consideration, the coefficients of Sin $\alpha$, and also of Cos $\alpha$, have the same sign, varying only in magnitude.

II. That for each observatory the maximum of negative errors occurs at about $6^h$ of Right Ascension, the maximum of positive errors at about $18^h$, the zero of error varying but little from $3^h$.

III. That the periodic error depending on the declination is zero at about 12° north.

That these discordances do not arise from systematic errors in the *Standard Catalogue* is shown by a comparison with the observations of Maskelyne (1765–1807), Struve (1825 and 1830), Argelander (1830), Struve (1845), and Newcomb (1870), which have not been used in forming it; and their real existence being thus established, they are referred by Professor Rogers to systematic errors in the provisional places of the stars on which the clock-errors depend, such errors being only eliminated to the extent of one-fifth of their amount in each revision. These errors appear to have been introduced originally by error in the form of Pond's transit pivots, the differential system of determining Right Ascensions having been adopted by Pond in 1816, and generally used in all observations since that date.

From the whole investigation Professor Rogers draws the following conclusions:—

I. The periodic errors of single period existing in observed Right Ascensions are in no sense inherent in the observations themselves, but are entirely transferred from the provisional places of the clock-stars on which they depend.

II. The accumulation of negative residuals in the region of $18^h$ is due to the unequal pivots of the Greenwich Transit, erected in 1816.

III. The accumulation of negative residuals in the region of $6^h$ is due partly to the general *drift* in the direction of the motion of *Sirius* and *Procyon*, and partly to errors developed indirectly from the combination of observations made with unequal or irregular pivots.

IV. The errors thus accumulated are distributed over the whole arc of Right Ascension by means of the formulæ :—

$$m \sin \alpha + n \cos \alpha.$$
$$m' \sin 2\alpha + n' \cos 2\alpha.$$

*Cornu's Determination of the Velocity of Light.*

A new determination of the velocity of light has been made by M. A. Cornu, Mining Engineer, and Professor at the Polytechnic School, Paris.

The method employed is optically the same as M. Fizeau's: a ray of light is sent between the teeth of a tooth-wheel, and reflected at a distant point, so as to bring it back to its point of departure; giving to the wheel a sufficiently rapid rotation, the ray, on its return, meets a tooth instead of a void space, and it is stopped; doubling the velocity, the ray again meets a void space, and it passes; and so on alternately, as the velocity increases. But the mechanical arrangements for determining the velocity of the wheel were entirely altered. The experiments were made between August 10 and 31, 1872, the two stations being, one of them at the Polytechnic School, the other at Mont Valerien, at a distance of 10,310 metres, being about once and a quarter the distance, 8,633 metres, of M. Fizeau's stations at Montmartre and Suresnes). The whole number of observations was 658; the velocity of light, as deduced from different groups of observations, ranged from 290,400 to 307,200 kilometres per second; the mean value, as given by the whole series, being 298,500 kilometres per second.

The velocity of light is connected with astronomical constants by the equation—

$$V = \frac{2\pi\rho}{T \tan \alpha \tan \epsilon},$$

where $\rho$ is the Earth's equatoreal radius, taken by M. Cornu at 9,378,233 metres; $T = 365{\cdot}25 \times 86{,}400$, number of seconds in the year; $\alpha$, the constant of aberration, $= 20''{\cdot}445$ (Struve's value); and $\epsilon$ the solar parallax. Taking the solar parallax successively at $8''{\cdot}90$ and $8''{\cdot}57$, the corresponding values of V, as astronomically determined, are $V = 296{,}200$ and $307{,}700$ kilometres per second. M. Fizeau's observed value, $V = 298{,}500$, gives a solar parallax $= 8''{\cdot}834$.

The full account is contained in the Memoir, "Détermination nouvelle de la Vitesse de la Lumière." Jour. de l'École Polyt. t. xxvii. cah. 44 (1874), pp. 133–180.

### *M. Le Verrier's Planetary Researches.*

The planetary researches of M. Le Verrier have now been extended to include the theories of all the principal planets. At a recent meeting at the Académie des Sciences, his theory of *Neptune* was presented, which thus completes his investigations of the fundamental theories of the planetary system. M. Le Verrier has taken this opportunity for making a short *résumé* of his labours in this important branch of Astronomy, and of the principal results obtained from his separate researches, which have been occupying his attention since 1839, the date of his first Memoir. The first planet whose orbit was investigated was *Mercury*, which was presented to the Académie in 1843; it was, however, afterwards reinvestigated and finally completed in 1859. That of the Sun, or Earth, appeared in 1853 and 1858, and those of *Venus* and *Mars* in 1861. The theories of *Jupiter* and *Saturn* were presented in 1872 and 1873; that of *Uranus*, first published in 1846, has been the subject of a new investigation presented in November 1874; and, finally, the theory of *Neptune* in December 1874.

Referring to his belief in the existence of some unknown cosmical matter between *Mercury* and the Sun, and which he considers to be the cause of certain anomalies in the theory of *Mercury*, M. Le Verrier makes the following remarks, which may well appear here. He says, "The comparison of the motion of *Mercury* with the theory we gave in 1843 did not from the first present a satisfactory result. The transits of *Mercury* over the solar disk furnished very accurate data, which it was impossible to satisfy completely. This first result gave us some uneasiness. Had we not allowed some small error in the theory to escape us? Fresh researches, in which everything was repeated by different methods, only ended by convincing us that the theory was exact, but still it did not agree with the observations. Many years passed, and it was not till 1859 that we were able to give a cause for these proved anomalies. We discovered that they resolved themselves into a simple law, and it was sufficient to increase the motion of the perihelion by thirty-one seconds in a century to restore everything into order.

"The displacement of the perihelion thus acquires an exceptional importance in the planetary theories. It is a certain index, when it has to be increased, of the existence of cosmical matter yet unknown, and revolving, like other bodies, around the Sun. It is of little consequence whether this matter is agglomerated in a single mass, or separated into a group of asteroids independent of each other. Provided that all these circulate in the same manner, their combined effect would have a tendency to give a direct motion to the perihelion. The consequence is

very clear. There exists, without doubt, in the neighbourhood of *Mercury*, between the planet and the Sun, matter altogether unknown. Does it consist of one or many small planets, or more minute asteroids, or even of cosmical dust? The theory is not able to decide the question."

A notice of M. Le Verrier's researches respecting the theories of the more distant planets was inserted in the last *Annual Report*, where it was stated that the comparison of the Tables of *Jupiter* had been satisfactorily made with the observations, and that the printing had commenced. This is now finished; and, by the kind assistance of M. Le Verrier, Mr. Hind has been enabled to give the tabular places of *Jupiter* in the *Nautical Almanac* for 1878, deduced from the new tables. The Tables of *Saturn* are also completed, and their comparison with the observations nearly concluded. It now only remains to make a comparison of the new theories of *Uranus* and *Neptune* with the observations to complete effectually this noble undertaking. M. Le Verrier has been assisted materially in the construction and laborious comparison of the Tables of *Jupiter* and *Saturn*, by M. Gaillot, Chef du Bureau des Calculs, with whose aid he looks forward with every confidence to a successful termination of his planetary investigations.

### *Theorell's Räknetabeller.*

This little volume of general tables, which has lately been published at Stockholm, under the title *Räknetabeller till underlättande af allmännast förekommande sifferkalkyler*, or "Tables for facilitating frequently occurring Arithmetical Calculations," may be found useful to the astronomical computer. It contains a table of multiples by 1, 2, . . . . 9 of all numbers from 1 to 1,000, by which multiplications producing ten, twelve, or more figures are easily effected, with the advantage of having every figure accurate. It also contains the numbers from 1 to 1,000, together with their logarithms, reciprocals, squares, cubes, square roots and cube roots, the roots being given to three, the logarithms to five decimals. There are several other tables, some of which are, however, too concise for general use; for instance, the logarithmic sines and tangents to five places are given for every minute only for the first seven degrees, and at longer intervals for arcs greater than seven degrees, but a small table is added for obtaining the sines and tangents of very small arcs. A table of foreign measures and weights is included, in which their equivalents are accompanied by their multiples, and also a small table of constants, with their multiples and logarithms. It concludes with an ordinary 5-figure table of the logarithms of numbers from 1 to 10,000. The book has a very neat appearance, is of convenient size, and printed on good paper.

*Todhunter's History of the Theories of Attraction and the Figure of the Earth.*

We omitted to notice, in last year's Report, the appearance of a valuable work by Mr. Todhunter, on the *History of the Theories of Attraction and the Figure of the Earth.*

The plan is similar to that of the same author's previous works on the *History of the Calculus of Variations*, and on that of the *Theory of Probabilities.*

In two octavo volumes, divided into thirty-eight chapters, the author gives a very complete analysis of the various researches which have been made in his subject from the time of their commencement by Newton in his *Principia* down to the completion of Laplace's *Mécanique Céleste.*

Thus in general the history is not carried beyond the end of the first quarter of the present century, but the author makes an exception to this rule in the cases of Poisson, Ivory, and Plana, and gives an account of all the contributions which these three mathematicians have made to the subject. The historical account is accompanied by critical remarks and rectifications, where necessary, of the original writers.

Besides the more purely mathematical parts of the subject, an account is given of the measurement of arcs of the meridian in Lapland and Peru.

Few branches of Physical Astronomy have been more prolific than this in beautiful theorems, or have led the way to more elegant and powerful mathematical methods.

This history is not intended to supersede the reading of the principal authors whose labours it records. On the contrary, the connected and methodical account of the various investigations which it gives will greatly facilitate the intelligent study of the original memoirs.

*Progress of Meteoric Astronomy during the Year* 1874.

Beyond the collection of observations and their discussion, little of more than usual interest appears to have been accomplished, or of remarkable facts recorded in this department of astronomy during the past year. Falls of aërolites were less abundant than in some previous years, only that of Vidin in Turkey, on the 20th of May last, and of Khairpur, India, September 23rd, 1873, having excited much attention. A few additional fragments of the aërolitic fall of Lancé (France), July 23, 1872, have lately been discovered, and a description of these and of the former aërolite was given by M. Daubrée in the numbers of the *Comptes Rendus.* Large bolides or fireballs have appeared in some abundance, and

a list of such occurrences was presented in the Report of the Luminous Meteor Committee to the British Association at their last meeting, from which it appears that none of those observed in England were of the detonating class. The August star-shower of last year was unusually brilliant, and plentiful records of its appearances were obtained; while, of the other annual star-showers of the past year, only that of the 20th of April 1874, was visible in England to advantage.* The meteor-tracks observed on these occasions await comparison and reduction, with those of many occasional shooting-stars communicated for some years past to the Committee, and only the following preliminary descriptions, as contained in the observers' notes, were given in their Report of the particulars of these showers. The first observed appearance of the annual star-shower of the 20th of April was that of a few *Lyraïds* visible in a clear state of the sky that began to prevail during the morning hours of the night of April 19-20. Their number sensibly exceeded that of the sporadic or unconformable meteors visible on the night of April 20, and, as has already been frequently noticed on previous occasions of its observation, the appearance of the shower was followed by a remarkable scarcity of meteors (with none from the radiant-point in *Lyra*) on the night of the 21st, with very little increase of frequency on the 22nd, although the sky was as clear for meteor observations on these as on the first night of the watch. The greatest hourly frequency of the *Lyraïds* was that observed for two hours towards and after midnight on the night of the 20th, when their number reached eight or nine per hour and several of the meteors seen exceeded the fixed stars in brightness. The position of the radiant-point was fixed by Mr. Greg two or three degrees *s. f.* from *α Lyræ* with an extension of the radiant region towards *Cerberus et Ramus* noticed by all the other observers as a concomitant radiant-region of the shower. The brightness of the August star-shower far exceeded that of any other meteor-shower during the year, and presented a sensible increase of intensity over its somewhat rich displays of the two preceding years, nearly approaching to that of its appearance in the year 1871. The rate of frequency for one observer on the night of the 10th was forty or fifty per hour; the hourly frequency on the following night being scarcely more than half that number, although the shower was still abundant, and the meteors bright, while on the nights of the 9th and 12th, as far as a clear view of the shower could be obtained, its numbers were comparatively insignificant. A striking feature of the shower was the distinctness of its time of maximum on the 10th, the brightness of its meteors, of which nearly one-half were

* That of December 10 and 11, 1874, was noted in France, at Toulouse, by M. Gruey (*Comptes Rendus*, vol. lxxx. p. 56). The radiant was well shown at 130°+46°; a position agreeing with that of the Tupman and Schiaparelli radiant-point of December 27th, to which reference in some further remarks (at p. 251) will be made below.

equal to or brighter than 1st magnitude stars, their uniform yellow or orange-yellow colour, and the persistency of their streaks, marking apparently a very central passage of the Earth through a concentrated portion of the *Perseïd* stream in the year 1874. A good determination of the radiant-point gives apparently three radiant-centres at R.A. 35°, N. Decl. 60°, R.A. 40°, N. Decl. 55°, and R.A. 54°, N. Decl. 62°, near the middle point of which was probably the true centre of divergence. A bright, perfectly stationary meteor was observed very near this point, at R.A. 45½°, N. Decl. 57½°. The result is in perfectly good accordance with the average direction of the stream from R.A. 44°, N. Decl. 56°, adopted by Schiaparelli in his comparison of the orbits of the *Perseïds* with that of the third comet of 1862.

No indications of re-appearance of meteors connected with the meteor-comets of November were noticed on the annual dates of the 14th and 27th of November last, although the large staff of meteor-observers, under M. Le Verrier's directions, watched especially for their returns. Perhaps a note for November 1873, in Mr. C. L. Prince's Summary of a Meteorological Journal kept in that year at Crowborough Beacon Observatory, Sussex, that "one large meteor and many small ones were observed on the evening of the 23rd," may relate to the only re-appearance, that has been recorded, since the showers of November 1872, of meteors connected with Biela's Comets, corresponding, as it does very nearly, in date with that of a considerable shower of *Andromedes* observed in America on the 24th of November 1872. Of the principal Bielan shower on the 27th of that month, a long list of meteor-tracks observed at Geneva and at Pesth is published by Dr. Weiss in the present volume of the *Annals of the Vienna Observatory* (in recent volumes of which the meteor-paths noted at that observatory during the years 1867–72 have also appeared), and the following radiant-points are thought by Dr. Weiss to be found from these observations to produce meteor-tracks in the following proportions :—

| | | | | | |
|---|---|---|---|---|---|
| R.A. | (1) 25°·0 | (2) 52°·2 | (3) 20°·8 | (4) 349°·3 | (Sporadic) |
| N. Decl. | 44°·2 | 49°·5 | 24°·6 | 40°·1 | |
| Proportion of recorded Meteors | 57 ℘ | 16 ℘ | 15 ℘ | 6 ℘ | 7 ℘ |

Herr N. von Konkoly communicates, from his Observatory of O'Gyalla in Hungary, a correction of the radiant-point of the same shower quoted (with some errors of reference) in the list of positions contained at p. 501, vol. xxxiii. of the *Monthly Notices*; and, with additional observations obtained elsewhere, this may be supplied as follows :—

| Observer. | Place and Time of Observation—G.M.T. | Position of Radiant-point. R.A. | N. decl. | Approx. by stars. |
|---|---|---|---|---|
| N. von Konkoly | O'Gyalla (Hungary) Evening | 26°·25 | 45°·0 | ($\pm 1\frac{1}{4}°$ in R.A., and $\pm 1°$ in Decl.) |
| M. H. Close | Near Dublin (Ireland) About $6^h$ to $10^h$ P.M. | 19°·0 | 45°·0 | Close to ξ *Andromedæ*. |
| Jos. Baxendell | Manchester $6^h\ 53^m$ to $12^h\ 19^m$ | 22°·5 | 44°·5 | Near χ *Andromedæ*. Centre of an oval area, 12° long and 9° broad, from mapped positions of 266 *Andromedes* (*Manch. Lit. and Phil. Society's Proceedings*, 1872, Dec. 10). |
| A. Brothers | Manchester $5^h\ 50^m$ to $8^h\ 30^m$ P.M. | 29° | 42° | At γ *Andromedæ*, a position most easy to note with accuracy in this shower (*Ibid*). |

Other matters of detail connected with his meteoric observations, it is remarked by Herr von Konkoly, require rectification in the description given of them in the *Monthly Notices*, vol. xxxiii. p. 576, and vol. xxxiv. p. 83. The numerous meteors noted by his assistant in July and August 1872 were seen with the naked eye, and not (as described at the former place) with the meteor-spectroscope, three meteors only of the shower having been thus examined by Herr von Konkoly himself, and the lines distinguished in their streaks being (as there related) those of sodium in all the three, and a line of magnesium in the streak of one of the meteors spectroscopically observed. In the account of a similar observation, with Browning's meteor-spectroscope and with a star-spectroscope, of the streak of a large meteor seen on the 13th of October 1873, a misstatement at the latter place is also pointed out of the kind of gas with whose spectrum, in a Geissler tube, four of the six spectral lines seen in the meteor-streak were found to coincide. Instead of "lightning [lighting] gas" as described, coal-gas (or one of the carburetted hydrogens, marsh-gas and olefiant gas) was, it appears, contained in the tube; and as, besides the lines of sodium and magnesium, four lines of this spectrum were found to coincide with the remaining bright lines visible in the meteor-streak, it is remarkable how clear a confirmation of the astronomically established connection between meteors and comets has thus been afforded by the spectroscope. The principles of gravitation, regarded by Mr. Lockyer as affecting primarily (according to the theory of the nebular hypothesis) the distribution of elementary substances among the differently gravitating systems and bodies of the universe, placing light-atomed substances generally at the most remote distances from their centres (a theory apparently not altogether unsupported in the structure of the Earth's crust and atmosphere itself), recur involuntarily to the mind in contemplating these first results of analytical examination by the spectroscope of those remotest of all outlying objects of the solar system, comets and shooting-stars, which occasionally present

themselves for its investigation; and the first ingredients detected in these bodies by the spectroscope appear to consist of elementary substances of very light atomic weights. The observations of position of the large meteor-streak were forwarded to Dr. Galle at Breslau, by whom particulars of the apparent paths of this and of other large fireballs lately visible in Germany, for the purpose of determining their astronomical orbits, have been collected.*

The course of a fireball (since the fall of the aërolites of Pultusk) to which Dr. Galle has most successfully applied his investigations is that of the 17th of June 1873, visible over Bohemia and the north-western provinces of Austria. The path of this meteor was directed from a height of about 100 English miles over a place in Hungary nearly midway between Pesth and Vienna to a point of explosion 20 miles above the Lausitzer mountains (at the extreme northern boundary of Bohemia), a path of 285 miles traversed by the meteor in ten seconds (from the best observations only); and the direction of the flight was from a radiant-point at R.A. 246°·7, S. Decl. 19°·3. The speed and direction of this motion belong to a hyperbolic orbit of even greater excentricity (2·379) than that of the fireball of Pultusk (2·277) obtained by Dr. Galle from a similar discussion of the observations of that meteor's course. A loud explosion accompanying its extinction, was heard to great distances in the district over which it disappeared, and the streak left upon its course, illuminated in twilight, at its great elevation, by the Sun's rays, remained visible for half an hour. Although presenting thus strongly the characters of an aërolitic fireball, a visit made by Dr. Galle (according to the experience gained from the stonefall of Pultusk) to the locality immediately underneath the point of the meteor's disruption and disappearance was attended by no discoveries of meteorites. Its depth of penetration into the atmosphere four or five miles lower than the Pultusk meteor, and its separation into fragments at disappearance mark it, however, as belonging to the class of aërolitic and detonating rather than to that of silent or deflagrating meteors, of which it may possibly be shown by observations that even the brightest meteors of true meteoric showers consist. Dr. Galle inclines to the opinion that aërolites as well as shower-meteors may have their origin in the disintegration of cometary nuclei, and that a dif-

* In a recent communication to the *Astronomische Nachrichten* (No. 2014), Herr von Konkoly describes new spectroscopic observations of the Perseïds, which he made in August last. The bright lines, especially of sodium (always visible) and magnesium in the streaks appeared in the nuclei as intensifications of their yellow or green colours. Other lines of the streaks in the red, apparently strontium or lithium (?), and many in the green and blue were noted. The latter were imitated in a spirit-flame by the addition of small fragments of iron with a very small quantity of copper. The prominence of the magnesium line is perhaps significant, as silicates of iron and magnesium constitute the minerals olivin and enstatite, the characteristic bases of the stony substance of aërolites.

ferent conclusion, drawn from examples among the former of frequent occurrences of hyperbolic velocities, must be regarded, in the existing state of knowledge of the actual velocities of different descriptions of meteor-flights, as calling for more positive and certain investigation in the case of ordinary shower-meteors to establish it more surely. In very close connection with the question of the origin of aërolites, Dr. Flight, Assistant in the Mineralogical Department of the British Museum, supplies a want in the history of recent falls which, since the close of Dr. Buchner's Catalogue of them in 1869, has left the scientific researches of chemists, geologists, and astronomers on these bodies almost inaccessible to general readers, by a series of papers in the *Geological Magazine*, beginning with the first number of this year, in which all the most important particulars of the falls and peculiarities of composition of the aërolites recorded since that date are intended to be reviewed. Among the new facts recorded in his first communication is the suggestive one, observed by Dr. Reinsch in the meteorite of Krähenberg, that the grains of iron pyrites and metallic iron contained in its thin glaze or crust present no signs of oxidation under the high heat to which they have been subjected. The surface must apparently have been vitrified by some igneous process, similar to that by which fulgurites are fused, before the meteorite's collision with the upper strata of the air, and in a tract of its luminous course from which, at least, oxygen was absent. In the meteorite of Morbihan also it is observed that grains of nickel-iron project not only through the smooth inner, but also through a rough outer coat with which it is, in some places, covered. The excessively high temperature of the gaseous flame which forms the fireball may, however, it should be observed, be sufficient to neutralise the affinity of oxygen for iron, and to dissociate from each other the chemical elements volatilised from the surface of the meteorite, so as, perhaps, to leave unoxidised upon its surface substances that would very readily be attacked by oxygen at a lower temperature.

Registration of meteors has been continued during the past year at the Radcliffe Observatory, Oxford, at Stonyhurst College, and at the Royal Observatory, Greenwich, where the results, in the greater part of their details, have been published annually. In the absence of its active Director, the Rev. S. J. Perry, at the Kerguelen's-land *Venus*-Transit Observation Station, it may be hoped that (as was recommended by Dr. Heis to the German observing parties) a study of meteors in the Southern Hemisphere, by the astronomers stationed and on their passage there, will replace the loss which this branch of observation for the last few months sustained at the College of Stonyhurst. Captain Tupman's and Professor Forbes' outward and returning voyages may thus also have been turned to good account, so that an addition should be made to the list of meteor-tracks recorded in the Southern Hemisphere, which may one day compete with the

enormous number of upwards of 7,000 such observations in the single year 1872, recently published, under the direction of Signor Schiaparelli, by the Italian Meteor Association. The list of meteor-tracks noted by Captain Tupman in the Mediterranean during the years 1869-71, with the radiant-points obtained from them (see *Monthly Notices*, vol. xxxiii. p. 298), has, during the past year, been printed and presented to observers by the British Association, with accompanying maps and instructions by Captain Tupman, to assist their observations. This list and numerous occasional observations of shooting-stars, collected since the same period by the Meteor Committee of the British Association, forms a growing collection, from which it may be expected that new radiant-points will be obtained on the completion of their reduction and discussion. The following is an enumeration of the total numbers of meteor radiant-points contained in the six general catalogues of meteor-showers hitherto published by various observers :—

| Authors. | Number of Radiant-points. | | References, &c. |
|---|---|---|---|
| Heis | 81 ... ... | | *Astronomische Nachrichten*, No. 1642 (1867), and *British Assoc. Reports*, vol. for 1873. |
| Schmidt | 17 Jan.–June<br>135 July–Dec. | | *Astr. Nach.*, No. 1756 (1869); and *Brit. Assoc. Reports*, vol. for 1874. |
| Heis and Neumayer | 39 ... ... | | From 2.088 meteors observed at Melbourne, 1858–63. Dr. Neumayer's Magnetical and Meteorological Observations at the Flagstaff Observatory, Melbourne. See *Brit. Assoc. Reports*, vol. for 1868, p. 405. |
| Schiaparelli | 189 ... ... | | *Entwurf einer astron. Theorie der Sternschnuppen*, p. 84. (From observations by Zezioli in 1867-69.) |
| Greg | 132 ... ... | | Compiled from his earlier and from the preceding Catalogues; *Monthly Notices*, vol. xxxii. p. 348; and (considerably enlarged) in the vol. of the *Brit. Assoc. Reports* for 1874. |
| Tupman | 102 ... ... | | *Monthly Notices*, vol. xxxiii. p. 300 (1873). |
| Total | 695 | | |

In Greg's new general list all the above radiants are so grouped and arranged together as to be included (perhaps arbitrarily) under scarcely more than 150 meteor-showers of certain annual dates or limited durations. Where greater accuracy of comparison is desired, it is necessary to recur from its general dates and average positions to the observations in the original catalogues from which it is derived, and to whose radiant-points it supplies a reference. Among many of these (Schiaparelli's, at least, excepted) it will be found that equal liberty as

regards duration and the assemblage together of neighbouring radiant-points under single characters or reference-numbers is more or less frequently adopted, making the recognition of correspondences between the lists difficult and uncertain. That the several lists agree together remarkably in many cases, enabling their numerous determinations to be comprised in a single list of one-fourth of the total sum of their extents without increased latitude of the resulting meteor-showers, is shown by the examples of conformity which the *Cygnids* and *Pegasids* of the August, and the *Taurids* or *Muscids* of the November shower-dates, and other multiple meteor-showers supply, the radiant being apparently scattered or the degree of its real complexity not being known. In comparing cometary orbits with the present long lists of meteor-showers, another element of uncertainty consists in the perturbations which may have separated the comet before its visibility from its associated meteor-stream, or which the latter may have undergone since the appearance of its comet by the lapse of time. Thus a comet which, like that of A.D. 1006, moved (as supposed by Pingré) in an orbit very similar to that of Halley's, would probably undergo very similar secular perturbations; and, its nodes advancing, like those of Halley's Comet, slowly upon the ecliptic—about 6° in the interval since its appearance, while the equinoctial point has, in the same time, receded 12° in the opposite direction, a star-shower which, according to the elements of this, and of a comet with a very similar orbit in the year B.C. 136, would have been encountered by the Earth on about the 28th and 30th of April respectively in those years, or, disregarding perturbations, on the 10th and 29th of May respectively at the present time, would, by the effect of secular perturbations similar to those of Halley's Comet (supposing the orbits elliptical) be retarded in its return still later by about 5 and 13 days. Among the comets which have nearly approached the Earth's orbit, Dr. Weiss has calculated (for the equinox of 1850, and neglecting perturbations) the nodal dates and centres of radiation of the hypothetical star-showers belonging to thirty,* two of which (of the Comet I 1861, and of Biela's Comet) were at the same time shown to be identifiable, as has since been fully confirmed by further observations, with great meteor-showers of April and November. Four others were matched by radiant-points in Heis and Neumayer's list for the southern, and three by meteor-showers in Heis' and Greg's lists for the northern hemisphere; two more on the publication of the lists of Schmidt and Schiaparelli; and three by a later examination of Greg's list.† Six more (in all, twenty-two comets

* *British Association Reports*, vol. for 1869, p. 304. The last two radiants in Weiss' original memoir (*Beiträge zur Kenntniss der Sternschnuppen*) are calculated for intersection of the Earth's orbit with parts of the tail of the great Comet of June 1861 on June 30·5; Radiant-point, R.A. 50°·7; S. Decl. 39°·2; and in a similar manner for the Descending Node of Comet III 1853.

† *Monthly Notices*, February 1873; vol. xxxiii. p. 260.

out of the thirty) can now be traced in Schmidt's and Tupman's lists; and of these last, continuing the list included, as thus described in the Report to this Society for 1873, the brief table on page 252 contains the astronomical positions. For Greg's radiant WZ two cometary radiants of Weiss' list, agreeing with it more nearly than the one assigned before, are now substituted for it, and a misprint in the declination of that meteor radiant-point (+27°) in the earlier list is at the same time corrected.

In a recently published review, by Professor Schiaparelli,* of Captain Tupman's Catalogue, five meteor-showers of that list were shown to coincide distinctly with radiant-points of ordinary shooting-stars obtained from Zezioli's observations. The first and last of these radiant-points, in particular, may be noticed as having presented resemblances (*vide* the former Report) to the Comets 1792 II, and 1680 of Weiss's list; not deriving, however, like other cometary radiant-points of the list apparently re-observed by Captain Tupman, much certain confirmation, or even additional probability from these agreements. In the subjoined tabular statement the particulars of the former comparisons with the Shower-comets 1792 II, 1840 I, and 1683, may be consulted in the earlier Report. A period of 190 years assigned to the latter comet might give reasons to expect its return, or its star-shower to be visible in the Southern Constellation *Centaurus*, about the middle of March, at the present time. The orbit of the Comet 1840 I is considered to have been hyperbolic. The comet of 1833 is inserted in the present list in the place of that of 1680, as having a rather closer radiant-point, and more probably producing meteor-showers than that comet, at about the date of the rejected star-shower ($M_{1, 2}$, and Schiaparelli, No. 23) associated with it in the preceding list.

| | | | |
|---|---|---|---|
| T. No. 4 | (180°+35°) | Jan. 4–31) | = Comet 1792 II ☋ |
| T. No. 5 | (185°+15°) | Jan. 5) | |
| T. No. 7 | (145°−25°) | Jan. 5) | = Comet 1840 I ☊ |
| T. No. 17 | (202°−28°) | Mar. 19) | = Comet 1683 ☊ |
| T. No. 102 | (130°+49°) | Dec. 23–27) | ? = Comet 1680 ☋ |
| Schiap. 189 | (137°+45°) | Dec. 27) | |
| Schiap. 23 | (134°+40°) | Jan. 31) | |
| Greg, $M_{1, 2}$ | (135°+40°) | Jan. 25–31 (*Max.*) | |
| = Comet 1833 (☋) | (135°+25°) | Jan. 27, at ⊕'s closest approach to the orbit) | |

* *Memorie della Società degli Spettroscopisti Italiani*, May 1874. A valuable paper, by Herr L. Gruber, on the radiants and computed orbits of the meteors of October 17-28 is reviewed in the same number of Professor Tacchini's journal. The author suspects a bifurcation of the main stream of meteors; and no corresponding comets are recognised as producing the several associated meteor-showers of this date.

| List, and Sign of Meteor-shower. | Date of Shower and of Cometary Node (1850). | Radiant-points. R.A. | Decl. | Comet, and its Node; Remarks, etc. |
|---|---|---|---|---|
| | | ° | ° | |
| Tupman, Nos. 11, 12 | 1870 February 3–10 | 208·5 | −22·5 | |
| | January 29 | 208·4 | −31·2 | 1718 ☊ |
| Tupman, No. 16 (suspected) | 1869 February 13 | 260·0 | 0 | |
| | February 13 | 271·8 | +11·8 | 1858 IV ☋ (*confer* 1854 II. Hind. Also corresponds with the Comets 1799 II and 1699 I, supposed to be probably identical). |
| Greg WZ ... ... | Mar. 15—Apr. 20 | 305·0 | +37·0 | |
| | (February 13 | 304·0 | +37·3 | 1854 IV ☋*) |
| | March 18 | 312·4 | +21·6 | 1763 ☋ (Elliptic, 1100–1700 yrs.) |
| | (April 4 | 302·0 | +11·0 | 1857 V☋ (Elliptic, 1618 yrs). } Supposed to resemble each other |
| | April 24 | 319·1 | +19·0 | 1790 III ☋ } and 1825 I (?). |
| Schmidt ... ... ... | September | 55·0 | − 6·0 | |
| | September 10 | 53·0 | −15·8 | 1854 III ☊ † (supposed to be possibly identical with the Comets of 1558 and 961). |
| Schmidt ... ... ... | September | 40·0 | − 8·0 | |
| | September 20 | 44·5 | −24·1 | 1763 ☊ |

* 1854 IV, Weiss = 1854 V (Hind). Regarded in the former list as corresponding with WZ.

† 1854 IV (Hind). No meteor-showers corresponding to any of the above radiant-points are contained in other lists. Their agreement with the corresponding cometary orbits is very incomplete; and from their slender representation in the Catalogues they do not appear to form parts of very conspicuous radiant-systems, or groups of meteor-streams.

Besides cases of very close approach at the node, it is conjectured by Weiss and Schiaparelli that the materials of the tails, or projected with the tails outside of the orbits, of certain large comets whose nuclei passed inside of the earth's orbit may occasionally give rise to meteor-showers. The same process of disintegration of the nucleus, although principally acting outwards, may possibly be attended by lateral and inward, as well as by outward extension of the meteor-currents in the plane of the comet's orbit. Cometary radiant-points corresponding to meteoric showers may thus be sought for, at least provisionally, among comets whose orbits pass within the earth's orbit at their node, and among others of small inclination and small perihelion distance, whose orbits, lying nearly in the plane of the ecliptic, have approached the earth's orbit very nearly at points not exactly coinciding with their nodes. Of comets belonging to the latter class, the number contained in catalogues is extremely small, and that of Lexell is one whose orbit presents an instance of this kind, of which the particulars have most frequently been noticed. Although the perihelion distance of the elliptic orbit in which it presented itself to observation is only two-thirds, and its distance from the Sun at the descending node little more than three-quarters of the Earth's mean solar distance, yet, at a point which the Earth passes about one month before reaching the line of nodes, the comet's track, owing to the small inclination of its plane (less than 2°) to the ecliptic, approaches the Earth's orbit (as the comet itself appears also to have approached the Earth) within less than one and a half million miles. The date of nearest approach is about the 6th of July, while the Earth's passage through the line of nodes occurs annually on the 6th of August. The radiant-point (as is remarkably the case for meteor-streams computed in this manner from cometary orbits lying nearly in the plane of the ecliptic) varies little with the time, being at R.A. 277°—284° S. Decl. 21°—22° in the beginnings of July and August, at 267°, —23° for the point of perihelion transit of the Earth through Lexell meteor-streams in the middle of September, and at R.A. 257°, S. Decl. 25°, for the point of nearest approach at the end of November (somewhat more distant than the first) of the meteor-stream in passing below the Earth's orbit after leaving perihelion. Four radiant-points occur in Captain Tupman's list (No. 36), observed in 1870, June 28–July 6, with an average position at 285°, —12°·5, that on June 29 being at 284°, —16°, with which Captain Tupman compares the mean position of two neighbouring radiant-points for June and July ($O_1O_2$) of Heis and Neumayer at 263°·5, —15°·5, and to a cluster of radiant-points for June and July near it in Schmidt's list. The nearest of the latter to correspond with a Lexell meteor-stream are the radiants for July 18–31, at 287°, —21°, and July 20–31 at 283°, —27°, which occur again for August 3–31, at 286°, —26°; they are only accompanied by one radiant near them of the same group, whose position is constant in June, July, and

August at 266°, −12°. No other observations of this radiant group between *Sagittarius* and *Ophiuchus* in the Via Lactea (below the cluster of *Antinöus*) are recorded in later months, and its correspondence in position during the months that it is visible with the radiant-point of Lexell's Comet makes it desirable to obtain further observations of this meteor-shower group which may throw more light upon its possible connection with the close approach to the Earth's neighbourhood and with the two supposed returns of that comet to the Sun. The number of comets whose orbits pass within the circle of the Earth's orbit at their node is, on the other hand, extremely great, and to compute all their approximate radiant-points on the principles above explained is an extensive task. It was in part accomplished, and the results are contained in the Report of the Luminous Meteor Committee presented to the British Association at their last annual meeting. Twenty-four new accordances, of more or less provisional exactness, of meteor-streams described in the various catalogues and cometary orbits are found by a preliminary comparison of the parallel lists; but as the assigned durations of the meteor-showers are often considerable, it is difficult to regard as more than possible and conjectural, at present, the numerous general agreements which are pointed out. The cases of closer accordance which it presents may proceed from so many latent contingencies of such difficult and uncertain comparisons and observations that it would be premature to select them from the list, where all the particulars of their descriptions will be found.

Besides the comets of 1680 and 1683, noticed by Dr. Weiss, the two long-period comets of the April and August meteor-showers, and those collected in the above Table, but two other well-defined examples of comets of long periods are found in this additional examination to be apparently connected with meteoric showers. Their radiant-points are both in the southern hemisphere, that of Comet I 1830 coinciding nearly with a meteor radiant-point in April, marked $\Gamma_4$; and those of the comets of 1264 and 1556 (expected by Mr. Hind to have completed another cycle, and to have presented a return in this century about the year 1860) with a radiant in March marked $\Delta_4$ in Heis and Neumayer's list. Of the certain comets of long period those of Halley and Pons only, passing somewhat inside the Earth's orbit at their node, appear to be possibly connected with meteor-showers; but without considerable latitude of the date, a shower noted by Schmidt in November and by Schiaparelli on the 12th of December cannot easily be reconciled with that of the Earth passing the orbit of Pons' Comet at the descending node on the 5th of December, and the agreements of position are, besides, not notably exact. The remarkably bright meteor-showers of April 29—May 2, 1870-71, in Captain Tupman's list have a date 16 days before, and a radiant-point 16° or 18° distant from the time and direction of the shower of tail-fragments that might have been encountered by the Earth in passing the descending node

of the orbit of Halley's Comet in 1835; yet no other observed meteor-showers present nearly so close an approximation to the ideal meteor-spray from Halley's Comet as this considerable display of shooting-stars described in Captain Tupman's list.

Of all the known comets of short periods, omitting Biela's and Lexell's, only three appear to have orbits favourably situated as regards the Earth's orbit for producing meteor-streams. Méchain's or Tuttle's Comet approaches it most nearly; but passing outside of it at an appreciable distance, it is, perhaps, for this reason that no meteor-showers corresponding to it have been hitherto observed. Of Burckhardt's (II 1766), Pons' (III 1819), or Winnecke's (I 1858), and of Clausen's (I 1743) or Blainpain's (IV 1819), the distance from the Earth at the nodes is rather greater; but as both of these comets (regarding them as perhaps constituting only two) are interior to the Earth's orbit where they approach it at their nodes, and the inclinations of their orbits are very small, the probability of their producing star-showers by the projection of meteor-substance in the direction of their tails appears to be somewhat greater. That of Clausen (I 1743), as separately computed by himself and others, has an inclination of only 2°, and the production of a continuous star-shower from this comet during the months of November, December, and January, with a radiant-point at about R.A. 10°, S. Decl. 2°, would present a very similar example of a long-enduring radiant-point to that of Lexell's Comet. In Dr. Schmidt's list of meteor-showers an extremely western radiant-point for December (not noticed by other observers) is recorded at R.A. 4°, S. Decl. 4°, which, if the imperfect observations and somewhat different computations of this comet's orbit (of the short period of $5\frac{1}{2}$ years) can be fully trusted, represents very closely the position of the comet's radiant-point. It was conjectured by Clausen to be identical with Blainpain's Comet (IV 1819), with a shorter period of $4\frac{3}{4}$ years; but the radiant-point of this comet is in much greater south latitude than that of Clausen's, and it does not appear to be represented by any meteor-system. Neither of these small comets, it appears, has been subsequently re-observed. Clausen also conjectured the identity of Burckhardt's Comet of short period (II 1766) with the similiar comet of Pons (III 1819) subsequently re-observed by Winnecke in 1858. Of these comets no corresponding star-shower is found in the Meteor Catalogues. The inclinations of their orbits are about 10°, and the perihelion distance of the first, at least, which lies near the node, is too small to favour such an expectation. While, however, it is impossible to attribute to the comet of Pons and Winnecke an appearance, described in the last volume of the *Monthly Notices* by Mr. Ranyard*, of a nebulous spot with a bright centre observed on the Sun's disk on the 26th of May 1828, and drawn with almost the same characters in his MS.

* *Monthly Notices*, vol. xxxiv. p. 26; November 1873.

observations by Pastorff as those which he is generally believed to have seen and similarly depicted of the nucleus of the second comet of 1819 in transit across the Sun's disk on the 26th of June in the latter year, yet it seems very probable that Burckhardt's Comet of 1766 may have returned to its node in 1828; and as the date of that conjunction in 1766 would be the 6th of June, allowing ecliptic limits of about 3°, the direct motion, small inclination and periodic time, and consequent rapid retrogradation of the node, apart from special perturbations, may explain a transit of the comet observed ten or twelve days earlier, on May 26, in the year 1828, than corresponds to the transit-time as given by Burckhardt's elements in 1766. The periodic time for twelve revolutions will be 5·174 instead of 5·025 years assigned by Burckhardt; and the nearest calculated time of a return to the node in August 1826 instead of in May 1828, is a discordance which would not be otherwise accounted for if Clausen's conjecture of the identity of this comet with that of Pons in 1819 did not prove its elements to be open to very wide corrections. Except in its inferior brightness, it otherwise resembled the second comet of 1819, being visible, with a short tail, to the naked eye; and it may thus, not impossibly, have been, like that object, the cause of one of the round nebulosities, or spot-like appearances on the Sun's disk represented in Pastorff's drawings.

It appears from this short summary that the best meteor-shower coincidences hitherto discovered are furnished by those comets whose orbits are decidedly periodic and approach the Earth's orbit very closely. Similar agreements observed with non-periodic comets, of which some close examples might be cited, are not, for the most part, so definite and precise. With the exception of the fine comets, 1618 III, and 568 II, perhaps contributing meteor-showers to the Lexell radiant group of Schmidt and Neumayer, in June and July, and the less conspicuous comets of 1764 and 1870 I, perhaps assisting to extend the duration of the shower of *Perseïds* before and after the annual date of its return on the 10th of August, and that two comets, 1840 I and 1818 III, regarded as having hyperbolic orbits, are comprised among them, few points of prominent interest, either in the comets, or in the corresponding meteor-showers with non-re-entering orbits, distinguish these agreements. The question whether non-periodic comets (as supposed by Schiaparelli) as well as those moving in orbits of long and short periods are associated with meteor-currents of greater or less length, and of varying density in different parts, accompanying them along their extremely remote and cosmically distant orbits, is accordingly still undecided; and the possibility of detecting long-flowing annual meteor-showers closely connected in their orbits with well-determined non-recurring comets must still be regarded as an open, and on account of its important bearing on other questions relating to the origin of meteors and aërolites, as a highly interesting and attractive subject of enquiry.

*Papers read before the Society from February* 1874 *to February* 1875.

1874.

Mar. 13. Notes on some Spectroscopic Observations of *Sirius*, *γ Argûs*, &c. Mr. Pringle.

On the Structure of the Solar Photosphere. Mr. Langley.

Notes to accompany Cromolithographs from Drawings of the planet *Jupiter*. The Earl of Rosse.

Occultation of *Neptune*, &c. Mr. Talmage.

Note on the Zodiacal Light. Mr. Knobel.

On the Obituary Notice of the late Rev. Temple Chevallier. Mr. Carrington.

On *Orion*. Mr. Barneby.

On two ancient Conjunctions of *Mars* and *Jupiter*. Rev. S. J. Johnson.

On the Zodiacal Light. Rev. S. J. Johnson.

Second paper on the Probable Variability of some of the Red Stars in Schjellerup's List. Mr. Birmingham.

Note on the Curvature of Lines in the Dispersion Spectrum and the method of correcting it. Mr. Christie.

On a Method of Drawing, by continued motion, a close approximation to a Parabola. Mr. Penrose.

On a Remarkable Structure visible upon the Photographs of the Solar Eclipse. Mr. Ranyard.

On the Solution of the Equations in the method of Least Squares. Mr. J. W. L. Glaisher.

Remarks on two papers by Mr. Stone, On the Treatment of Observations. Mr. J. W. L. Glaisher.

On a Determination of Longitude by Chronometers by the late Hastings F. Murphy, R.E. Mr. Lecky.

Apr. 10. The Solar and Planetary Systems. Mr. Hall.

On the Lunar Semidiameter derived from Occultations of Stars. Mr. Neison.

Observations of Eclipses of *Jupiter's* Satellites. M. Tisserand.

On the Appearance of round Bright Spots on *Jupiter*. Mr. Lassell.

On the Number of distinct Terms in a symmetrical or partially symmetrical Determinant. Prof. Cayley.

On the Opposition of *Juno*, with a view of determining the Solar Parallax with the Heliometer. Lord Lindsay.

Naked-eye Observations of *Jupiter's* Satellites. Mr. Denning.

Corregendum in the Results of Astronomical Observations at the Cape of Good Hope, Appendix, p. 449. Capt. J. Herschel.

On a piece of Apparatus for carrying out Janssen's method of observing the Transit of *Venus*. Mr. De La Rue.

Observations of *Jupiter's* Satellites. Mr. Gledhill.

May 8. Note on Mr. Christie's paper on the Curvature of Lines in the Dispersion Spectrum. Mr. Simms.

Observations of *Jupiter* in April 1874. Mr. Brett.

On a Method of enlarging Lunar and Solar Photographs so as to correct the Spherical Aberration. Herr Zenger.

On a Method of finding the Parallax of Double Stars; and on the displacement of the Lines in the Spectrum of a Planet. Prof. Niven.

Continued Observations of the Companion to *Procyon*. M. O. Struve.

On the Discovery and Elements of Comet II 1874, and Comet III 1874. Mr. Dunkin.

Discovery of Minor Planet ([137]). M. Palisa.

On an Apparatus designed for the photographic record of the Transit of *Venus*. Signor Capello.

Bright Spots on *Jupiter*. Mr. Gledhill.

On the fixing of Spider Lines in Collimators and Transit Telescopes. Capt. J. Herschel.

On the Combinations of the different Results of various series of Observations. Herr Powalky.

June 12. Note on Drawings of *Jupiter* made at Parsonstown and by M. Terby at Louvain. Earl of Rosse.

Lunar Occultations of Stars and Eclipses of *Jupiter's* Satellites. Mr. Tebbutt.

Note on *Sirius*. Mr. Wilson.

Remarks on the Influence of the Error of Observation on the Determination of the Orbit of a Planet from Observations. M. Berg.

Observations of Occultations of Stars by the Moon . . . and the Phenomena of *Jupiter's* Satellites in 1874. Rev. R. Main.

Notes in reply to Sir J. Herschel's Queries relative to Double Stars. Mr. Burnham.

A Fourth Catalogue of 47 new Double Stars. Mr. Burnham.

Note on the Double Star Σ 707. Mr. Burnham.

Note on the Double Stars Σ 1801 and OΣ 265. Mr. Burnham.

Observations of the Total Solar Eclipse of April 16, 1874. Mr. Stone.

Definitive Elements of the Comets I 1801, I 1824, III 1840, and II 1869. Dr. Doberck.

Third Paper on the Probable Variability of some of the Red Stars in Schjellerup's List. Mr. Birmingham.

Observations of *Jupiter*. Mr. Knobel.

On a New Form of Position Micrometer. Mr. Bidder.

Discovery of Minor Planet ([138]). M. Perrotin.

Observations of the Zodiacal Light. Mr. Fasel.

Periods of Revolution of four Double Stars, from recent Observations. M. Flammarion.

Observations at Churt of the Values of Co-latitude given by *η Ursæ Majoris* on the Prime Vertical. Mr. Carrington.

Note on the Comparison of a Star in the Radcliffe Catalogue with others in the same Catalogue. M. d'Abbadie.

Nov. 13. On certain Phenomena presented by the Satellites of *Jupiter* while in Transit, &c. Mr. Burton.

On the Inner Satellites of *Uranus*. Mr. Holden.

On the Application of Corrections for Change of Temperature to the Ratio of two Chronometers during a Voyage from Liverpool to Calcutta. Mr. Nevins.

Spectroscopic and Meridional Observations of Coggia's Comet (III 1874) made at the Royal Observatory, Greenwich. Sir G. B. Airy.

Observations of Coggia's Comet made at the Cape of Good Hope. Mr. Stone.

Note on the Polarisation of Coggia's Comet. Mr. Ranyard.

Sextant Observations of Coggia's Comet. Mr. Anderson.

Observations of the Satellites of *Neptune* and *Uranus* at the U.S. Naval Observatory. Rear-Admiral Davis.

Observations, &c., of Coggia's Comet. Mr. Tebbutt.

Comparison of Mean Places of Stars observed at Oxford in 1871 with places given in the *Berliner Jahrbuch*, 1871. Dr. Wolfers.

Note on the Discovery and Elements of Minor Planet ([139]). Mr. Dunkin.

Note on the French Expedition for the Observations of the Transit of *Venus*. Mr. Dunkin.

Sextant Observations of Coggia's Comet in South Africa.

On the present state of M. Delaunay's Investigations on the Lunar Theory. Prof. Newcomb.

On the Observations of *Flora* made for the Determination of the Solar Parallax. Dr. Galle.

Relation between the Motions of some of the Minor Planets. Mr. Kirkwood.

On the Brightness of $\mu$ *Draconis*. Rev. S. J. Johnson.
Remarks on ancient Chinese Eclipses. Rev. S. J. Johnson.
The Duplicity of the Principal Star of $\nu$ *Scorpii*. Mr. Burnham.
A Fifth Catalogue of New Double Stars. Mr. Burnham.
Note on Coggia's Comet. Mr. Wilson.
Observations of *Iapetus*. Mr. Lassell.
Observations of Coggia's Comet. Mr. Ellery.
Note on the Zodiacal Light. Mr. Plummer.
Drawings of Comet III 1874 (Coggia). Mr. Plummer.
On certain Phenomena seen during Eclipses of the Sun, and their bearing on the Question of a Lunar Atmosphere. Mr. Brett.
Note on the Distribution of Stars from the 1st to the 6·7th magnitude. Mr. Kropotkin.

Dec. 11. Hyperbolical Elements of Comet I 1845. Dr. Doberck.
Ephemerides of 12 Circumpolar Stars suitable for the Determination of Azimuth Error. Prof. Pritchard.
On a New Astrometer. Mr. Knobel.
On Personality in observing Transits of the First and Second Limbs of the Sun. Mr. Dunkin.
Extract from a Letter to Dr. Robinson on Nebulæ, &c. Mr. Ellery.
Phenomena of *Jupiter's* Satellites. Mr. Gledhill.
On an Equestrian Equatoreal. Rev. E. L. Berthon.
Solution of the Problem connected with Mr. Knobel's Astrometer. Mr. Gray.
On the very much extended Nebulæ of Sir John Herschel's General Catalogue. Mr. Cleveland Abbe.
Telegrams relating to the Transit of *Venus* received by the Astronomer Royal. Sir G. B. Airy, K.C.B.
Comparison of the times observed at Alexandria with Le Verrier's, Carlini's, and Lindenau's Tables. Mr. Hind.
On Professor Holden's Paper on Observations of the Satellites of *Uranus*. Mr. Marth.

1875
Jan. 8. Further Ring-Micrometer Observations of Coggia's Comet (III 1874). Mr. Tebbutt.
Note on the Probable Disappearance of two Stars of the 6th magnitude from the cluster B. A. C. 2694. Mr. Tebbutt.
On Proctor's Equal Surface Chart. Mr. Parkhurst.
Observations of Occultations of Stars by the Moon, and of Phenomena of *Jupiter's* Satellites, made at the Royal Observatory, Greenwich, in the year 1874. Sir G. B. Airy, K.C.B.
Observations of the Solar Eclipse of October 9, 1874,

made at the Royal Observatory, Greenwich. Sir G. B. Airy.

Observations of the Transit of *Venus* at Mauritius. Lord Lindsay.

Observations of the Transit of *Venus* at Luxor, Egypt. Admiral Ommanney.

A Preliminary Catalogue of Nebulæ. Dr. Schultz.

Ephemeris of Physical Observations of *Jupiter*. Mr. Marth.

Extract of a Letter to Mr. Browning on the Observation of the Transit of *Venus*. Colonel Campbell.

*List of Public Institutions and of Persons who have Contributed to the Society's Library, &c., since the last Anniversary.*

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## ADDRESS

*Delivered by the President, Professor Adams, on presenting the Gold Medal of the Society to Professor Heinrich D'Arrest.*

It has been already announced to you that the Council have awarded the Society's Medal to Professor H. L. D'Arrest, Director of the Observatory of Copenhagen, for his Observations of Nebulæ contained in his *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen* and in his later and much more extensive work, *Siderum Nebulosorum Observationes Havnienses*, as well as for his other recent astronomical labours. It now becomes my duty to lay before you the grounds of this award; and I feel confident that a plain statement of the nature and extent of the work accomplished by Professor D'Arrest will be sufficient to convince you that he richly deserves our medal.

Professor D'Arrest has been long well known for his contributions to our science. No reader of the *Astronomische Nachrichten* can fail to have been struck by the untiring activity shown by his numerous communications to that periodical, so indispensable to the astronomers of all countries. Among his discoveries I may refer to that of the interesting periodical comet which bears his name, and likewise to that of the minor planet *Freia*, the 76th member of the group of small planets between *Mars* and *Jupiter*, the known number of which now amounts to 142, and is yearly increasing at a rate which shows no signs of slackening.

But of all the labours of Professor D'Arrest, unquestionably the most important are his observations of nebulæ contained in the two works mentioned at the commencement of this address.

These works would, in the opinion of your Council, even if they stood alone, amply justify the award of your medal.

Nearly forty years have elapsed since the Society's medal was awarded to Sir John Herschel for his Catalogue of Nebulæ and Clusters of Stars, printed in the *Philosophical Transactions* for 1833. In his address on that occasion, the Astronomer Royal gave an able sketch of the history of our knowledge of the nebulæ up to that time, which makes it quite unnecessary for me to go over the same ground, necessarily much more feebly. I may merely recall that the three catalogues of Sir William Herschel, published in the *Philosophical Transactions* for 1786, 1789, and 1802, contain the places and descriptions of 2500 nebulæ and star-clusters. Sir John Herschel's catalogue contains the results of his observations made at Slough, with his 20-foot reflector, between the years 1825 and 1833. These observations were undertaken for the purpose of reviewing the

nebulæ and star-clusters discovered by his father. The catalogue comprises 2307 of these objects, about 500 of which are new.

Not content with having made this survey of the heavens visible in this latitude, Sir John Herschel resolved to undertake a similar survey of the southern heavens; and for this purpose he transported to the Cape of Good Hope the same instrument which he had employed in the northern hemisphere, "so as to give a unity to the results of both portions of the survey, and to render them comparable with each other."

The observations required in order to carry out this grand plan were made in the years 1834, 1835, 1836, 1837, and 1838, and the fruits of these prolonged labours appeared in 1847, in the magnificent work, *Results of Astronomical Observations made at the Cape of Good Hope*. The survey included the double-stars of the southern hemisphere, as well as the nebulæ and star-clusters. The work contains a catalogue of 1708 of these latter objects, entirely similar in its arrangement and construction to the Catalogue of Northern Nebulæ in the *Philosophical Transactions for* 1833, and reduced to the same epoch (1830), in order to facilitate the union of the two catalogues into one general one. Of these objects 89 are common to the two catalogues, so that the number of distinct nebulæ and clusters which they contain is 3926. Both of these works of Sir John Herschel contain engraved representations of some of the most remarkable nebulæ, whether of typical or of exceptional form, by means of which future observers may be able to ascertain whether any secular changes are perceptible in them. The latter work also comprises valuable chapters on the apparent distribution of the nebulæ over the heavens, and on their classification, together with many general remarks on the phenomena presented by them, which have been suggested by the author's long experience.

By these labours of Sir William and Sir John Herschel, and by them almost exclusively, astronomers had now obtained a considerable amount of knowledge respecting the apparent distribution of the nebulæ over the heavens, and respecting their forms and physical structure as seen through powerful telescopes.

Their distances from us, however, and therefore their real distribution in space and their actual magnitudes remained matter of speculation only.

Sir William Herschel, having found that many nebulæ, which in inferior instruments showed no traces of stellar composition, were, when viewed by his powerful telescopes, resolved entirely into stars, was at first inclined to believe that all nebulæ were so resolvable. Hence he was inclined to regard them as so many galaxies, similar in their nature to our Milky Way, and owing their nebulous appearance to the enormously greater distances from us at which they were situated. Longer experience, however, induced him completely to change his views.

Already in 1791, in a paper on Nebulous Stars, he had arrived at the conclusion that there exists a diffused self-luminous matter

"in a state of modification very different from the construction of a sun or star," and that a nebulous star is one "which is involved in a shining fluid of a nature totally unknown to us," and "which seems more fit to produce a star by its condensation than to depend on the star for its existence."

Again, in his paper on the Construction of the Heavens, in the *Philosophical Transactions* for 1811, he shows that although the appearances presented by diffused nebulous matter and by a star are so totally dissimilar, yet that these extremes may be connected by a series of such nearly allied intermediate steps as to make it highly probable that every succeeding state of the nebulous matter is the result of the action of gravitation upon it while in a foregoing one, and that by such steps the successive condensation of it has been brought up to the condition of planetary nebulæ, and from this again to a stellar form.

From the appearances presented by the planetary nebulæ he infers that the nebulous matter is partially opaque, since the superficial lustre which these objects exhibit could not result "if the nebulous matter had no other quality than that of shining, or had so little solidity as to be perfectly transparent."

He also suggests that comets may be composed of nebulous matter in a highly condensed state, and that the faint nebulous branches which are often seen appended to a nucleus may be similar to the Zodiacal Light in relation to our Sun.

In the same paper he finds reason to conclude that the distance of the faintest part of the great nebula in *Orion* probably does not exceed that of stars of the 7th or 8th magnitude, but may be much less, perhaps even not exceeding the distance of stars of the 2nd or 3rd order, and consequently that "the most luminous appearance of this nebula must be supposed to be still nearer to us."

These views of Sir William Herschel respecting the gradual formation and growth of stars by the condensation of nebulous matter were still further confirmed and developed in his paper in the *Philosophical Transactions* for 1814.

Sir John Herschel's graphic description of the two Nubeculæ, or Magellanic clouds, likewise clearly shows that irresolvable nebulæ, resolvable nebulæ, and clusters of stars represent luminous matter in different conditions, but not necessarily at very different distances from us.

The direct measurement of the distance of a nebula by determining its annual parallax must be regarded as nearly hopeless. The nearest known fixed star has a parallax of scarcely one second. Now the error to which we are liable in the determination of the place of a nebula, although, as we shall see, it may under favourable circumstances be made much smaller than has been commonly supposed, still considerably exceeds one second. Hence, unless a nebula were much nearer to us than the nearest fixed star, there would be no chance of our being able to determine its parallax.

There is one method, however, by which we may expect ultimately to throw great light on the mutual relations of the nebular and sidereal systems, and on their relative distances from us: I mean by the study of their proper motions. Of course, no definite conclusion respecting the distance of an individual nebula could be drawn from the observation of its proper motion. For a nebula comparatively near to us might still have a very small proper motion, simply because its motion in space was nearly equal and parallel to our own. If a large number of instances, however, were taken, it might be asserted with a high degree of probability that those bodies which had a large proper motion were on an average nearer to us than those whose proper motion was small.

Now we know, at least approximately, the proper motions of many of the fixed stars, and materials are gradually accumulating which will give us a much more accurate and extensive knowledge respecting them; but of the proper motions of the nebulæ we know little or nothing.

Unfortunately for this object, the instruments of Sir William Herschel were not well adapted for the very accurate determination of the places of nebulæ. He himself estimates that after 1785 the uncertainty of his places might amount to $1\frac{1}{2}$ minute of space in R.A., and from $1\frac{1}{2}$ to 2 minutes in Declination, and that his earlier observations were liable to much greater errors. Hence these observations can scarcely be employed in such a delicate research as that of the determination of proper motions.

The degree of accuracy attained in Sir John Herschel's two catalogues is much greater. The author considers the probable error of a single observation in his northern catalogue not to exceed $1\frac{1}{2}$ second of time in R.A., and 30″ in Declination. In his Cape Observations he estimates that the error of a single observation will seldom exceed 30″ of space in the direction of the parallel, or 45″ in that of the meridian.

Both of these catalogues give the results of the separate determinations of the place of a nebula, and therefore afford the means of calculating the probable errors of the observed places.

Professor D'Arrest has thus found that the probable error of a single position is nearly 15″ in R.A. and 19″·5 in Declination.

Considering the comparatively recent date of these observations, however, it is plain that a considerable time must elapse before the comparison of Sir John Herschel's observations with later ones of a similar degree of accuracy can be expected to yield trustworthy results respecting the proper motions of the nebulæ.

M. Laugier was the first who attempted to determine the places of certain selected nebulæ with much greater precision than is attained in Sir John Herschel's catalogues, in order that they might furnish a secure foundation to future investigations respecting proper motion. In the *Comptes Rendus* of December 12,

1853 (tome xxxvii. p. 874), he gives a catalogue of the places of 53 nebulæ for the beginning of 1850, selecting such as had well-defined centres or points of greatest brilliancy. It is to be regretted that no details are given respecting either the number of observations on which the places in the catalogue are founded, the mode of observation, or the telescope employed, so that the catalogue itself affords us no means of judging of the degree of accuracy of the places contained in it.

Professor D'Arrest's first series of observations on the nebulæ began in May 1855, and, like M. Laugier's, had for their object the accurate determination of positions for the express purpose of affording means in due time of studying the proper motions of the nebulæ, and thence arriving at more certain conclusions respecting the relations between the nebular and sidereal systems than could be attained by the mere contemplation and examination of the objects themselves, even with the aid of the most powerful telescopes. The results of these observations were published in the *Transactions* of the Royal Saxon Society of Sciences for 1856. The number of nebulæ observed amounts to 230. The observations were made at the Leipzig Observatory, of which Professor D'Arrest was then the Director, with the Fraunhofer refractor of $4\frac{1}{3}$ French inches in aperture and 6 feet focal length, by means of a Fraunhofer's double ring-micrometer. The magnifying power usually employed was 42 times. The nebulæ were thus directly compared with neighbouring stars out of Bessel's and Argelander's Zones. In one night usually three and sometimes four transits of a nebula and its comparison-star were observed, the transits being taken alternately in the northern and southern halves of the ring-micrometer. In order to guard against the uncertainty which may still remain in the places of the stars of comparison, Professor D'Arrest often gives, in his description, the observed differences of right ascension and declination. He also often gives the position of the nebula with respect to the nearest stars, frequently those of the 10th and 11th magnitude, which must ultimately prove most useful for the determination of the nebula's proper motion. In this last point he followed the excellent practice of Sir John Herschel; but he was able to make more repeated measures of this kind, since, on account of the comparatively small power of the instrument, the description of the objects was of secondary importance. It should be remarked that all these measures were taken with the ring-micrometer, no mere estimations being admitted except when they are expressly mentioned. The results derived from each night's observations are given separately. The places given in the catalogues of Sir William and Sir John Herschel and in the small catalogue of Laugier are likewise reduced to the same epoch (1850) for the sake of comparison.

We are so much accustomed to think of the observations of nebulæ in connection with the most powerful instruments, that it will be no doubt a matter of surprise that a refractor of scarcely

$4\frac{1}{2}$ inches aperture should have been found suitable for such work. Professor D'Arrest, however, from his experience with such an instrument, estimates that it is capable of showing nearly a thousand nebulæ, that is about a third part of all that have been observed in our latitudes with the most powerful telescopes. He remarks also that the small nebulæ of Herschel, mostly round or elliptical in form, can have their places determined more accurately than the majority of telescopic comets. Besides, in observing nebulæ, there is the immense advantage of being able to repeat the observation of one and the same place on different nights. The prevailing central condensation in nebulæ, which sometimes attains a degree of concentration almost stellar, and which very frequently offers a well-defined nucleus, gives a great degree of definiteness to the observation. Those nebulæ which, for various reasons, cannot be observed accurately are, according to Professor D'Arrest, comparatively less numerous. Of the 53 nebulæ observed by Laugier, 31 have been re-observed by Professor D'Arrest. Excluding one of Laugier's right ascensions, which is evidently affected with a large error, and three of the declinations, which appear to be about 1′ in error, perhaps through mistakes in copying, and assuming the probable error of one of Laugier's positions to be equal to that of the mean of three of his own single positions, Professor D'Arrest finds each of these probable errors to be about 6″ both in right ascension and declination. By a provisional calculation of the probable error of his observations, founded on a comparison of the several determinations with their mean, Professor D'Arrest finds that the probable error of a definitive position, that is of the mean of the observations of three nights, generally depending on 9 transits, does not exceed 4 or 5 seconds of space in each co-ordinate.

Professor D'Arrest makes an interesting use of his comparisons of his own places with those of Sir John Herschel. The mean epoch of Sir John Herschel's observations is nearly 25 years earlier than that of his own. Hence the difference between the places of a nebula as given by the two authorities, and reduced to the same epoch, will include not merely the errors of the observations, but also the proper motion for 25 years and the difference of the star-places used in the reductions. Now, from the probable errors of Sir John Herschel's and Professor D'Arrest's places which have been already ascertained, we can at once obtain the value of the mean of the squares of the differences between those places, supposing the differences to be entirely due to casual errors of observation. The actual mean of the squares of the differences is found to be greater than the above-mentioned mean, and the excess is due partly to the proper motions of the nebulæ in the interval, partly to the differences in the star-places employed, and, very probably also partly to constant differences in the mode of observing the same nebula by the two observers. Hence Professor D'Arrest concludes

that the probable amount of the annual relative motion of the nebulæ with respect to the sidereal system is less than 0″·4 measured in arc of a great circle.

I may appropriately conclude my remarks on Professor D'Arrest's *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen* by a quotation from one who has himself done much in the same line of research. Speaking of Laugier's and D'Arrest's observations, Dr. Schultz says: "These works have the high merit of having originated a new and important branch in the study of the nebulæ; and D'Arrest has done especial service to this study by showing that, when what is required is simply good determinations of positions, a much greater number of nebulæ than has been usually supposed may be advantageously observed with instruments of but very moderate dimensions. But his series of observations is chiefly and especially important as proving beyond the possibility of a doubt that the positions of nebulæ in general are determinable with far greater accuracy than it had been previously usual to suppose; and D'Arrest's work thus made an epoch in the study of nebulæ, by freeing it from the deterring prestige which had before that period been attached to it."

Many other observers have since followed up the work thus begun by Professor D'Arrest. Very accurate positions of nebulæ have been observed by Auwers, Schmidt, Schönfeld, Vogel, Rümker, Stephan, Schultz, and others. I may particularly mention Schönfeld's Mannheim Observations of 235 Nebulæ, which appear to be extremely accurate and are published in a form that leaves nothing to be desired. This work also enjoys the immense advantage that the places of all the stars of comparison have been newly determined by the meridian observations of Professor Argelander. But a still more extensive work in the same field, and which promises to attain even a greater degree of accuracy, is that by Dr. Schultz, from whom I have quoted above. This work consists of micrometrical observations of 500 nebulæ made at the University Observatory of Upsala, with the Steinheil 13-foot refractor, employing a parallel wire-micrometer with bright spider-lines on a dark field.

By means of the various series of observations to which I have referred, future astronomers will be provided with a rich store of materials for the study of the proper motions of the nebulæ, and we may hope that even in our own time some valuable results may be arrived at respecting them.

Professor D'Arrest's observations of nebulæ were interrupted for a time by his appointment as Director of the Observatory of Copenhagen. In no long time, however, his new position gave him the opportunity of resuming his observations with the aid of greatly increased optical power. In the year 1861, the Observatory acquired a magnificent refractor, by Merz, of 15 feet focal length and 10½ French inches in aperture, of which Professor D'Arrest has given an elaborate description in a separate publication, *De Instrumento magno æquatorio*. He considers

this instrument to be intermediate, as regards optical power, between Sir John Herschel's 20-foot reflector in its best condition, and the excellent telescope with which Mr. Lassell made his observations at Valletta. Finding that with this instrument he could not only perceive the very faintest of the nebulæ discovered by the two Herschels, but could make sufficiently precise observations of them, he resolved no longer to continue the work begun in Leipzig, where he confined his attention to selected nebulæ, but to enlarge his plan of operations and make a survey of the nebulæ of the whole of the northern heavens. At first, indeed, it was his intention to observe all the nebulæ he should meet with, whether previously known or not, with the utmost attainable precision, and that not once or twice only but repeatedly. He soon found, however, that to carry out such a plan, especially in such a climate, was beyond human powers, the number of the nebulæ far exceeding all expectation. After labouring assiduously and perseveringly at these observations for more than six years, Professor D'Arrest was at length compelled by failing health to bring his work to a close. He estimates that in those six years he had not been able to make more than about one-eighth of the total number of observations which would be required in order to form a catalogue of the approximate positions of those nebulæ which could be accurately observed with the Copenhagen refractor.

The results of these prolonged labours have been published in the great work, *Siderum Nebulosorum Observationes Havnienses*, 1867. This volume contains about 4800 single positions of 1942 different nebulæ. Of these about 390 have either not been previously observed, or have not had their places determined. Sir John Herschel's Northern Catalogue of Nebulæ and Clusters of Stars contains a larger number of objects, viz., about 2300. The difference between these numbers partly arises from the fact that D'Arrest has designedly omitted those objects in Herschel's catalogue which, in his judgment, should not be classed with the nebulæ, viz., clusters and collections of stars belonging to Sir William Herschel's sixth, seventh, and eighth classes. These clusters appear to have no necessary connection with true nebulæ, and they are distributed over the sphere in a totally different manner. The number of such clusters, especially near the Milky Way, might be easily greatly increased; and in making his sweeps, Professor D'Arrest has often been surprised to find certain clusters inserted in Herschel's catalogue, while several others in the same neighbourhood were omitted. The selection appears to him arbitrary and by no means natural. He thinks too that the introduction of these objects would tend to vitiate any inquiries into the law of distribution of the nebulæ.

By far the greater number of the nebulæ cannot be observed at all with bright wires, or at any rate can only be so observed by great expenditure of time and trouble. Hence Professor D'Arrest did not attempt to define their places with all the precision of which his instrument was capable, but brought each nebula into the

centre of the ring-micrometer, the smallest radius of which was 3′ 40″. The power employed in determining all these approximate positions was 123. The hour circle was read off to integral seconds of time, and the declination circle to tenths of a minute of arc.

In fact, nearly the same method was followed which astronomers are accustomed to employ in finding the places of very faint comets. Thus everything was scrupulously avoided which would interfere with the keenness of vision, and the more precise definition of place was generally left to micrometrical observations and comparisons with minute stars situated in the immediate neighbourhood of the nebula.

The nebulæ were generally observed in zones of about 4° or 5° in breadth, and in each zone 4 or 5, or even sometimes 7 fixed stars of the 7th or 8th magnitude were included, whose places were taken from Bessel's or Argelander's zones, or sometimes from those of Lalande.

The work contains about 4000 micrometrical measures. chiefly made with the ring-micrometer. More rarely nebulæ were compared with the stars and with each other by means of the wire-micrometer. Bright and small nebulæ, having stellar nuclei, or at least an entirely regular form, were observed with all possible precision, and the differential determinations of their positions referred to neighbouring stars will, without doubt, be found of the greatest importance in the future study of their proper motions.

Excluding a few nebulæ, whose places do not admit of any accurate determination, Professor D'Arrest finds, from 1627 observations of declination of 525 nebulæ, that the probable error of a single observation of declination is 17″·58, while from 1552 right ascension observations of 497 nebulæ, he finds the probable error of a single observation of right ascension to be $0^{s}\cdot809 \sec \delta$.

These probable errors are slightly less than the corresponding probable errors of Sir John Herschel's catalogues.

Following the excellent example set by Sir John Herschel, Professor D'Arrest gives the results of each night's observations of a nebula separately, both as regards its place and its description.

The use of an equatoreally mounted telescope has no doubt rendered this catalogue comparatively free from incidental errors and mistakes in the identification of nebulæ, which will occasionally happen, in spite of the greatest care, when the observations are made with an instrument not so mounted.

Lord Rosse's valuable selection from the observations of nebulæ made with his gigantic reflector of 6-feet aperture appeared in the *Philosophical Transactions for* 1861, but, curiously enough, did not reach Professor D'Arrest's hands till 1864, when his own work was considerably advanced. This work contains sometimes brief and sometimes full descriptions of about 800 nebulæ, many of them being illustrated by figures. Professor D'Arrest found that not a few of the nebulæ which he had detected in the interval between

1861 and 1864 had been already observed by Lord Rosse and his assistants, and that his descriptions were generally confirmed by theirs. Very many "new" nebulæ, however, still remained which had not been observed by Lord Rosse; while, on the other hand, many which occur in Lord Rosse's work had escaped the notice of Professor D'Arrest. After this period he derived the greatest assistance from Lord Rosse's work. It is not surprising to find occasional differences and discrepancies in the descriptions of nebulæ given in these two works. Professor D'Arrest mentions that he has found and observed by far the greater part of those nebulæ which had been observed by Herschel, but had been inserted by Lord Rosse in a list of "nebulæ not found."

He also succeeded in verifying the existence and determining the places of many very faint nebulæ, which had been first discovered by means of Lord Rosse's telescope.

In the *Philosophical Transactions for* 1864, Sir John Herschel published his *General Catalogue of Nebulæ and Clusters of Stars*, and thereby laid astronomers under another very heavy obligation. This excellent catalogue contains all the nebulæ and clusters of stars, both northern and southern, actually known at that date, 5063 in number, arranged in order of right ascension, and reduced to the common epoch 1860. A short description of each nebula or cluster is given in abbreviated words, made out from an assemblage and comparison of all the descriptions of each object given in his father's and in his own observations.

It is not easy to over-estimate the boon which such a catalogue offers to an observer of nebulæ, by enabling him "at once to turn his instrument on any one of them, as well as to put it in his power immediately to ascertain whether any object of this nature which he may encounter in his observations is new, or should be set down as one previously observed." As Sir John Herschel remarks, "For want of such a general catalogue, a great many nebulæ have been from time to time, in the *Astronomische Nachrichten* and elsewhere, introduced to the world as new discoveries, which have since been identified with nebulæ already described and well known. Many a supposed comet, too, would have been recognised at once as a nebula, had such a general catalogue been at hand, and much valuable time been thus saved to their observers in looking out for them again."

While Sir John Herschel was engaged in the preparation of this catalogue, an important work by Dr. Auwers appeared, entitled, *William Herschel's Verzeichnisse von Nebelflecken und Sternhaufen, bearbeitet von Arthur Auwers*, Königsberg, 1862. This contains a complete and most elaborate reduction to 1830, from the observed differences in right ascension and polar distance with known stars, recorded in the *Philosophical Transactions*, of all the nebulæ and clusters in Sir William Herschel's three catalogues; together with a separate catalogue of all those collected by Messier from his own observations or those of Méchain and others (101 in number), similarly reduced; another

of Lacaille's southern nebulæ; and one of fifty "new nebulæ, comprising nearly all those observed by other astronomers (Lord Rosse excepted) in this hemisphere, all brought up to the same epoch."

Sir John Herschel states that a comparison with Dr. Auwers' results led him to the detection of several grave errors in his own work which would otherwise have escaped notice, and whose rectification has added materially to its value.

Sir John Herschel's general catalogue contains the places and descriptions of 125 of the new nebulæ discovered by Professor D'Arrest, and reduced by him to the epoch of that catalogue.

At the end of his own work Professor D'Arrest gives a catalogue of the mean places of his 1942 nebulæ, reduced to the epoch 1860 for comparison with Herschel's general catalogue. He also gives a comparison of his own positions with the places of 223 nebulæ contained in the very accurate special catalogue by Schönfeld, which has been already mentioned.

In the above rapid sketch I have omitted to mention the many excellent descriptions and delineations of particular nebulæ which we owe to Mr. Lassell, Professors W. C. Bond and G. P. Bond, Mr. Mason, Otto von Struve, Padre Secchi, and others.

I must not terminate this very imperfect account of the principal additions to our knowledge of the Nebulæ which have been made in recent years, without referring to the entirely new mode of investigation to which they have been subjected by means of the spectroscope. By observations of this kind, Mr. Huggins and others have thrown much additional light on the nature and constitution of these mysterious bodies. Already the spectra of about 140 nebulæ have been examined, and the light from many of them has been proved to emanate from glowing gas. This entirely confirms the mature view of Sir William Herschel, viz., that the condition of the luminous matter in many of the nebulæ is widely different from its condition in the fixed stars.

Professor D'Arrest has himself contributed to the spectroscopic observations of the nebulæ, and he has made the suggestive remark, that almost all the gaseous nebulæ are found either within or near the borders of the Milky Way, and that there is an entire absence of them in the regions near the poles of the galaxy, in which the other nebulæ so abound. I believe that a similar remark was made about the same time by Mr. Proctor.

It is worth mentioning that one of the most remarkable of these gaseous nebulæ, viz. the planetary nebula numbered 4373 in Sir John Herschel's General Catalogue was observed as a fixed star by Lalande in 1790, and that by comparing its place so determined with the very accurate modern determinations of Schönfeld, D'Arrest, and others, it has been shown that the proper motion of this nebula is quite insensible.

I trust that the statement, however bald and imperfect, which I have just laid before you respecting the labours of Professor D'Arrest, will have convinced you that your Council have been fully justified in awarding to him the Society's medal.

*The President then, delivering the Medal to the Foreign Secretary, addressed him in the following terms:*

Mr. Huggins—In transmitting this medal to Professor D'Arrest, you will express to him the admiration we feel for the skill and perseverance which he has shown in his observations of the nebulæ, and our high appreciation of the value of his labours. You may assure him of our ardent wishes that health and strength may long be spared to him, so that he may be able to make many further contributions to the progress of Astronomy.

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The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

*President.*

J. C. Adams, Esq., M.A., F.R.S., Lowndean Professor of Astronomy, Cambridge.

*Vice-Presidents.*

Arthur Cayley, Esq., M.A., F.R.S., Sadlerian Professor of Geometry, Cambridge.
Warren De La Rue, Esq., D.C.L., F.R.S.
William Lassell, Esq., LL.D., F.R.S.
Lord Lindsay, M.P.

*Treasurer.*

Samuel Charles Whitbread, Esq., F.R.S.

*Secretaries.*

Edwin Dunkin, Esq.
A. Cowper Ranyard, Esq., M.A.

*Foreign Secretary.*

William Huggins, Esq., D.C.L., LL.D., F.R.S.

*Council.*

Captain William de W. Abney, R.E.
Sir G. B. Airy, K.C.B., LL.D., F.R.S., &c., Astronomer Royal.
Sir Edmund Beckett, Bart., LL.D., Q.C.
W. H. M. Christie, Esq., M.A.
J. W. L. Glaisher, Esq., M.A.
George Knott, Esq.
Rev. Robert Main, M.A., F.R.S., Radcliffe Observer.
Captain William Noble.
Rev. S. J. Perry, F.R.S.
Rev. Charles Pritchard, M.A., F.R.S., Savilian Professor of Astronomy, Oxford.
Captain G. L. Tupman, R.M.A.
J. Maurice Wilson, Esq., M.A.